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ANALYSIS—The Key to Chemistry

• By Lockhart B. Rogers, Ph.D., *(Princeton University)*
ASSOCIATE PROFESSOR OF CHEMISTRY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS.

In the early days of chemistry, the identification and characterization of new substances shared the limelight with their preparation. However, as chemistry grew and the emphasis shifted to finding applications for new compounds, analysis, though a necessary step, became more nearly routine. During the last ten years a rebirth of interest in analysis has developed as a result of challenging problems in the field of "trace analysis" and the introduction of techniques borrowed from the physicists and electrical engineers.

Experiments in coulometry, polarography, spectrophotometry and chromatography are representative "trace" methods which have been outlined to demonstrate how one can use these analytical techniques to provide training in basic principles of chemistry.

This paper is a condensation of an address before the New England Association of Chemistry Teachers, Boston, December 4, 1954.

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Historical Role of Analysis

Analytical chemistry is the application of the science of measurement to chemical systems. The fact that each substance possesses a unique combination of chemical and physical properties permits one to detect its presence in a mixture and to determine the amount present. In the early days of chemistry, the preparation and characterization of new substances received most of the attention of chemists. However, as the production of new substances markedly increased, methods of analysis were developed and then standardized so that they could be performed successfully in a routine way. Unfortunately, this side of analysis was the only one that was recognized by many chemists and other scientists until about ten years ago. At that time the spectacular work done on the Manhattan project, where there had been stringent requirements on the purity of uranium and other materials, forced the development of "trace" methods for the impurities and drew attention of fellow scientists to the vital non-routine role of analytical chemistry. At the same time, there had been a growing realization in a number of fields of the almost ubiquitous role of trace elements and a resulting demand for determinations of those elements when present in concentrations of parts per million or sometimes parts per billion. For example, trace elements have been found to be vital factors in the nutrition of plants and animals; in the proper functioning of germanium transistors; in affecting the color of fluorescent light and TV screens; and in accelerating corrosion of metals.

Fortunately for the analytical chemist rapid advances have been taking place in electrical engineering which have made it possible to obtain commercially many specialized instruments of the physicist, such as infrared and X-ray spectrometers. The availability of such special instruments has often been the crucial link which made it possible for the analyst to accomplish determinations at the trace level. Though many of the techniques are highly specialized, the purpose of the present discussion is to demonstrate how several of the "trace techniques" can be used as excellent vehicles for teaching fundamental principles of chemistry.

Faraday's Law—Coulometry

Apparatus

The small beaker or a test tube is used as the electrolytic cell and is filled with an appropriate electrolyte. One "working electrode" is the place at which the desired reaction takes place. The electrode is most conveniently made by sealing approximately 10 cm. of moderately sturdy coiled platinum wire into the end of a 5 mm. i.d. glass tube by melting the end of the tube around the wire. Electrical contact with the wire can be made in a variety of ways, one of which is to fill the tube with mercury.

A second electrode can be made the same way, using only one or two centimeters of the platinum wire. This electrode is not placed in the electrolytic cell but instead in a tube of electrolyte (often the same as that of the electrolytic cell) connected electrically to the cell by means of a "salt bridge." The latter consists of a short piece of glass or Tygon tubing containing 3% agar gel plus 0.1M potassium nitrate or potassium chloride. The purpose of the salt bridge is to prevent any of the products generated at the second electrode from making contact with the solution in the electrolytic cell and possibly interfering with the reaction going on there.

As a source of electrons, one may use a battery or dry cell having a voltage from 6 to 90. In series with the electrolytic cell connect a large resistance, between one thousand and one million ohms, so that its value is large compared to the resistance of the rest of the circuit. This large resistance and the voltage of the battery will be the chief factors which determine the magnitude of the current that will flow through the circuit. One can determine exactly the magnitude of the current in the circuit by connecting a small known resistance in series with the large one and measuring the potential drop across it using a student potentiometer. If the drain on the battery is small, the current flowing through the circuit will usually be constant to 1% or less for many minutes on end. After using a stop watch to measure the duration of the electrolysis, one can easily calculate the number of coulombs required for the reaction.

Experiments

1. One can deposit a small amount of copper or silver from a 1M copper sulfate or silver nitrate solution respectively. From the weight of the deposit and the number of coulombs one can calculate the equivalent weight of the element. To illustrate why coulometry is important in trace analysis, it is instructive to calculate the weight of the element which corresponds to one microampere-second.

2. The reverse experiment involving dissolution of part of a deposit can also be run and the results compared with the first one. In most cases, the data from the dissolution are less reliable due to the fact that mechanical losses of the element from the electrode often take place.

3. Using a millimolar solution of hydrochloric or sulfuric acids containing one or two drops of phenolphthalein or a similar acid-base indicator, one can generate hydroxyl ion by liberating hydrogen at the "working" electrode. From the number of coulombs one can calculate the equivalent weight of the acid.

4. In a solution containing approximately O.1M hydrochloric acid plus 1.OM sodium iodide or ferric chloride one can produce iodine or ferrous ion respectively, and can determine the amount of substance produced by titration with standard sodium thiosulfate or potassium permanganate.

The above experiments serve to illustrate not only the principle of chemical equivalence but also those of oxidation and reduction.

EMF Series—Polarography

Apparatus

The electrolytic cell and salt bridge used in coulometry can also be used in polarography. However, as a working electrode, one exposes only a 1-2 mm. length of platinum wire. If mercury is available, it is desirable to assemble another working electrode, a dropping mercury electrode (D.M.E.) which consist of a 4-6 in. section of 0.05 mm. i.d. "barometer tubing" (Corning Glass Works) which can be obtained from any chemical supply house[1]. When the reservoir is 20 to 50 cm. above the tip of the dropping electrode, drops of mercury will fall at 3 to 5 sec. intervals in a solution of an electrolyte such as O.1M potassium chloride.

The second electrode should be a reference electrode with a large working area so that its potential will stay constant while currents of the order of microamperes are passed through it. If mercury is available, one can assemble a saturated calomel electrode by covering the bottom of a 100 ml. beaker or erlenmeyer flask with mercury, covering the mercury surface with an intimate mixture of potassium chloride and mercurous chloride crystals and then adding a solution of saturated potassium chloride. Electrical contact with the mercury layer is obtained through a small platinum wire sealed into a glass tube as described earlier. Such an electrode has a potential which is 0.246 V. more noble than the standard hydrogen electrode. As an alternative electrode one can seal a silver foil of about 10 sq. cm. area into a glass tube and dip it into 1.OM hydrochloric acid. Its potential is about 0.222 V. more noble than the standard hydrogen electrodes.

Electrical Setup

Attach the ends of a meter-stick slidewire across a 1.5 V, or preferably 3.0 V, dry cell attaching the positive lead from the battery to the zero end of the slidewire. A resistance of about 100 ohms in the slidewire is quite satisfactory. Attach another lead between the positive end of the slidewire and the reference electrode. Attach a final lead between a sliding contact on the slidewire and the working electrode—either the platinum micro electrode or the dropping mercury electrode. From a knowledge of the voltage of dry cell and the position of the sliding contact, one can determine the voltage on the working electrode. In order to determine the amount of current flowing through the cell it is necessary to connect in series with the polarographic cell a microammeter having an internal resistance of 5,000 ohms or less. It will be desirable to have this microammeter shunted so as not to injure it, and at the same time to enable one to measure several ranges such as 0 to 10, 0 to 20, and 0 to 50 microamperes. As an alternative, one can substitute for the microammeter a small resistance and a student potentiometer as was done in the coulometry experiment.

Descriptive Background

Different metal ions, when present in a concentration range of 10^{-3} to 10^{-4} M will give currents ranging from 10 to 0.5 microampere (using more sensitive equipment one can analyze 10^{-6} M solutions. Calculate the weight of copper in one ml. of such a solution.) In order to reduce the resistance of the solution of the sample, one usually adds an electrolyte such as O.1M sodium chloride, sodium nitrate, sodium sulfate, sulfuric acid or sodium hydroxide. Upon applying a potential to a dropping mercury electrode one will observe that the current grows and falls with each mercury drop. One records simply the maximum current at a given potential. With the platinum electrode the current will increase every time the voltage is changed, but it will settle down to an approximately constant value after one minute.

The advantage of using a dropping mercury electrode is that the surface of each drop is always clean so that the data can be readily reproduced. However, when using the platinum electrode it is necessary to strip off any deposits after completing a current-voltage curve before making a second curve.

Ordinarily one reads the current at intervals of 0.1 volt in going from 0 to about 2 volts. One will observe very little increase in current until the potential becomes sufficiently great for a reduction to take place (decomposition voltage), following which further increases in voltage will result in large increases in current. After an interval of 0.1 to 0.2 volts, the current will then increase more slowly and will finally flatten off, showing that ions are being reduced as fast as they reach the surface of the electrode. In the presence of a second reducible ion, the existence of another S-shaped curve will be found at higher voltages. Using a D.M.E. under ideal conditions, the position of each wave, as measured by the center of the S-shaped portion, but not by the "decomposition voltage," is charac-

teristic for the element in the particular "background electrolyte," (such as potassium chloride) which is present.

Polarography permits one to show not only the close correspondence with the e.m.f. series, but also its fallibility because the positions of certain of the elements will shift in relation to one another depending upon the background electrolyte. For example, in an alkaline solution containing ammonia and ammonium chloride, nickel is reduced to the metal 0.2 V more easily than cobalt. However, in a neutral solution containing 1 M tartrate cobalt is reduced with difficulty but nickel does not reduce at all.

Before getting into the experiments, one important factor should be noted. Because oxygen is readily reduced (very close to zero voltage) and because its reduction is very erratic, one ordinarily eliminates it from the solution by bubbling nitrogen through the solution for five minutes before starting a polarogram. The interference from oxygen can also be eliminated from alkaline solutions by putting in a pinch of sodium sulfite. Unfortunately, the deleterious effect of the presence of oxygen means that the electrolytic cell must be covered at all times and, preferably, must have an atmosphere of nitrogen over the solution throughout the period of analysis.

Experiments

1. A 0.1M solution of potassium chloride containing millimolar lead chloride or cadmium chloride should be deaerated with nitrogen for five to ten minutes and then analyzed by proceeding first in 0.1 V intervals and later at 0.02 V intervals in the region where the wave is found. Each reading on the current-voltage curve should be plotted upon graph paper as soon as obtained. Lead or cadmium can be examined using either a platinum electrode or a dropping mercury electrode.

2. If a dropping mercury electrode is employed, it will be helpful to look at a mixture of ions such as those of copper, lead and zinc in a nitrate or chloride medium. The copper is extremely easily deposited and comes out at zero applied potential. Lead deposits 0.2 — 0.4 V later, whereas the zinc is difficult to deposit and comes out only a few tenths of a volt before the rapid evolution of hydrogen makes measurements at larger potentials impractical.

3. In the case of copper, one can follow the reduction behavior at more noble potentials by reversing the leads on the electrodes, and making the platinum electrode increasingly positive (in addition to obtaining the usual type of polarogram obtained at negative potentials). It is helpful to compare the deposition behavior of copper in 0.1M potassium chloride and in 0.1M sodium sulfate in order to emphasize the important role played by the background electrolyte. In the chloride medium the reduction of copper takes place in two steps, the first corresponding to a reduction to cuprous ion and the second to the metal.

4. Only after the well-behaved metals have been explored should one try to obtain polarograms of oxygen. This can be done by putting into the cell a solution of potassium chloride that has been exposed to the air for some time. One can also explore the effect on the oxygen wave of adding successive drops of freshly prepared 0.1% gelatine to a 20 ml. portion of electrolyte.

Light Emission and Absorption— Spectrophotometry

Chemists are familiar with the characteristic flame tests produced by solutions containing alkali or alkaline-earth halides. Instead of dipping a nichrome or platinum wire into a solution containing the alkali metals and then into the flame of a burner, connect a source of compressed air to an atomizer in the form of a nose-sprayer. The resulting spray can then be added to the air stream going to a Bunsen burner or may be blown directly into the flame. The higher the concentration of an element, the more intense will be its color in the flame so it is only necessary to have available a photographer's exposure meter and suitable light filters (which may be obtained from Eastman Kodak Company or from the Corning Glass Works) in order to make quantitative measurements. The change in the reading on the meter will be proportional to the difference in the concentrations of two solutions. By proper selection of the light filter one can in principle prevent all except the desired wavelengths from reaching the light-sensitive cell. Hence it is possible to analyze mixtures of sodium and potassium for first one element and then the other. Such an analysis is frequently performed on blood serum in clinical laboratories. Under optimum conditions one can detect less than one microgram of sodium per milliliter of solution.

Experiments

It is also possible to perform two simple experiments illustrating absorption of light by colored solutions. Set an exposure meter face upward on a desk and cover the barrier-layer cell with a suitable light filter. Set a beaker of water on top of the filter and add some acid and a few drops of phenolphthalein indicator. Titrate with an alkaline solution base under a strong light. The change in the meter reading corresponds to the endpoint as shown by the change in color of the indicator.

A second experiment may be set up with a series of solutions containing different concentrations of permanganate or of copper sulfate.[2] These may be used to illustrate the quantitative relationship between concentration and the intensity of a color, known as the Lambert-Beer Law:

$$\log \frac{I_0}{I} = kcl$$

where I_0, the reading on the meter with only water in the beaker, is an arbitrarily assigned value of 100. I is the percentage that the reading changed when a colored solution was substituted for the water, k is a proportionality constant, c is the concentration of the solution, and l the depth of the solution. From the statement of the law, it is obvious that concentrations can only be compared when using equal depths of solutions. Likewise, one can determine relative depths of different portions of a single solution. This basic law holds not only in the visible region of energy but also in the ultraviolet, infrared and X-ray regions.

Some substances absorb light very effectively even in very dilute solutions. Permanganate is one of these; acid-base indicators do, also. It is very instructive to determine the amount of a substance which will produce a barely observable deflection of the meter upon substituting its solution for one of water.

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The Grand Canyon National Monument, A Scientist's Mecca

• By Walter P. Cottam, Ph.D., *(University of Chicago)*
DEPARTMENT OF BOTANY, UNIVERSITY OF UTAH

Since 1906, eighty-six national monuments have been set aside by presidental proclamation under the Act for the Preservation of American Antiquities. These monuments serve to preserve historic landmarks and other objects of historic or scientific interest.

This article describes a relatively unknown national monument and the almost unlimited opportunities it offers for scientific study.

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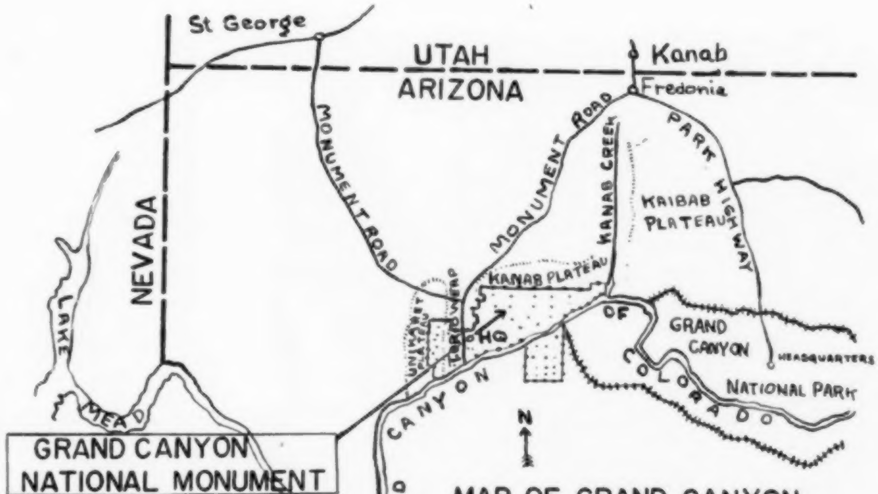
Because relatively few people have visited the Grand Canyon National Monument, there is some confusion regarding the distinction between it and the Grand Canyon National Park. The Monument area lies west of the Park but is contiguous with it, the dividing line being the Kanab Creek, which skirts the west base of the Kaibab Plateau. From Fredonia, Arizona, near the Utah-Arizona border, highway 89 proceeds southeasterly 82 miles to the North Rim Headquarters of the Grand Canyon National Park. In a southwesterly direction from Fredonia an unsurfaced road leads to the Monument Headquarters, 70 miles distant. Between the two headquarters, North Rim on the east and Toroweap on the west, is a 55 mile roadless wilderness practically inaccessible to man and essentially unknown to biological science.

The Grand Canyon National Monument has a total area of approximately 375 square miles. The river enters the area just south of the northeast corner, runs in a diagonal, undulating line southwestward and leaves the monument at the southwest corner. Except for a rectangular block 6½ by 9 miles including a jutting segment of the Coconino Plateau lying south of the river, the southern boundary of the Monument follows the northern bank of the river. In dimensions this scenic preserve is approximately 30 miles long and 18 miles wide in the area of the Coconino Plateau, but elsewhere the width varies from 15 miles on the west to 5 miles on the east.

The only ingress into the Monument is through Toroweap Valley, located near the west boundary. The long north-south axis of this valley heads almost imperceptibly in the vicinity of Mt. Trumbull and terminates suddenly and precipitously at the north rim of the canyon approximately 20 miles to the south. Both east and west the valley is sharply delineated by the escarpments of the Kanab and Uinkaret plateaus respectively. "At the foot of the valley the western wall is nearly 1,500 feet high, the eastern 2,000, and the interval separating them is about three miles. Suddenly they turn at right angles to right and left, and become the upper wall of the Grand Canyon of the Colorado. The Toroweap now opens to the main passageway of the great chasm[1]."

But the view is generally obstructed until one ascends to the east the 500 foot escarpment of the Toroweap Fault. Here a colossal scene of unexcelled grandeur bursts into view. Northeastward the diagonal and sharply serrated walls of the outer gorge may be followed by the eye for a distance of 40 miles before they vanish into the dim, blue mist of the Kaibab Plateau. Southwestward across the Toroweap, another twenty miles beyond, the outer gorge with its sharp, dendritic segments of plateaus projecting far above it is lost in a circuitous path to the distant, faded mountains that obscure the Colorado's entrance into Lake Mead. Southward the apparently unbroken but rough, red sandstone floor of the outer gorge extends in width for a deceptive distance of five miles, where it terminates in the steep, red talus base supporting the perpendicular, gray limestone walls of the Coconino Plateau 2,000 feet above. North and almost overhead, Toroweap point of the Kanab Plateau—a counterpart of the Coconino—towers



MAP OF GRAND CANYON

THE INNER GORGE of the Grand Canyon always gives the visitor a breathtaking experience. There is a deceptive 3,000 foot drop to the river, which at this place is more than 100 yards wide.

Over the six miles of rugged terrain from the river's edge to the summit of Mt. Emma, one passes through all the life zones of low elevations to be found in America, from the hot parched deserts of Lower Sonora, Mexico, to the cool, aspen-clad forests of Alberta, Canada. Major plant communities of the warm temperate desert include: streamside thickets, grasslands, microphyll shrub and chaparral types. Of the cold temperate desert there are deciduous shrubs, desert grasslands and pigmy forests of juniper and pinyon pine. Mountain shrubs and ponderosa pine communities are representative of the submontane types, and there are small patches of quaking aspen of the mid-montane belt.

For the biogeographer no spot in the West offers more exciting opportunities for study than the Grand Canyon National Monument. Here northern and southern desert forms intermingle in unusual abundance. Probably nowhere else can the ocotillo, Acacia, mesquite, creosote bush, Whipple's yucca, pinyon pine and Utah juniper be found in such close juxtaposition. The presence here of the ocotillo, separated as it is by a distance of close to 200 miles from its continuous range, and of the Whipple's yucca by even a greater distance, presents problems of distribution that challenge investigation.

far into the blue. To the northwest the clear outline of the Uinkaret Plateau, pimpled by numerous volcanic cones that pleasingly serve to break the gradually ascending horizon, terminates in the flat topped Mt. Trumbull. The gray walls of the Uinkaret escarpment are seen to be irregularly obscured by black tongues of lava flows that in times past filled the jagged bottom of Toroweap Valley and continued on to cascade over the precipitous chasm of the Colorado. But from this vantage point the chasm itself is nowhere in evidence. One must continue on for another mile and a half before the 3,000 foot deep abyss usually stops him in his tracks. Momentarily one may be emotionally disturbed, but eventually there comes the reward of a sublime experience. Vexation, however, is likely to follow any attempt to describe it with pen or film.

Opportunities for Scientific Study

That great scholar, explorer and geologist C. E. Dutton[1], who studied the Toroweap segment of the Monument area in 1880, said, "It would be difficult to find anywhere else in the world a spot yielding so much subject-matter for the contemplation of the geologist; certainly there is none situated in the midst of such dramatic and inspiring surroundings." This observation, I am persuaded, should apply equally well for the field biologist. Many factors have conspired to make it so. From the river's edge, at a little less than 1,700 feet in elevation, to the summit of Mt. Emma, where an elevation of 7,698 feet is reached, is an altitudinal differential of 6,000 feet within a distance of 6 miles. Soils are extremely diverse, with their parent materials derived from sandstone, limestone, shales, schists, pomace and hard lava. A playa lake and other flooded areas in Toroweap Valley show rather high salinity and alkalinity, while less than three miles distant in the forested zone of the Uinkaret Plateau, soils of slightly acid reaction are found.

For the plant taxonomist few areas in the United States offer such an expanse of unexplored territory. Practically the entire outer gorge beyond a day's hiking distance is unknown to the botanists. From the diverse areas accessible from Toroweap Valley on single-day trips, a total of 470 species of vascular plants have been identified.

The zoologist and especially the ornithologist will find the Grand Canyon National Monument essentially unworked. Mr. John Riffey, superintendent of the Monument, and his wife Laura—two enthusiastic and competent naturalists — through sight identification alone list 132 birds, 13 mammals and 15 reptiles. The Uinkaret Plateau, a forested island in a great desert expanse, appears to be a minor flyway for birds. Here in the solitude of magnificent ponderosa pines far removed from the sights and sounds of man, the June air reverberates with the medleys of grosbeaks, finches, sparrows and warblers in one grand choir of voices. Far below on the desert rim of the canyon as twilight approaches, the mockingbird, perched on some tall desert shrub, repeats over and over again the refrains of a dozen voices he has heard during the day, while the roadrunner silently and swiftly pursues his prey seemingly oblivious to all the beauty of the world about him.

The mammals of the monument include the mountain lion, bobcat, ringtailed cat, coyote, spotted skunk, mule deer, the vanishing mountain sheep and doubtless many species of rodents. Little if any trapping has been done in the Monument area, and the nocturnal rodents especially are unknown.

The area is comparatively rich in reptiles. There are several species of lizards and snakes, including three species of rattlesnakes. The Grand Canyon rattler, with a color that matches the vermillion shades of the sandstone walls and mesas, is of course an endemic species, but the common desert rattler and the rarer blacktailed cousin both generate the same warning sounds and never fail to attract their fair share of attention. It is always a thrill to observe the Gila monster and chuckwalla, two of the canyon's larger and more interesting reptiles. But the swift flight of the whiptail and collard lizards is always an amazing sight too.

Some Historical Notes

Historically, the Monument area of the Grand Canyon was perhaps the first bit of the Arizona Strip country to be visited by white men. Father Escalante's[2] party on October 16, 1776, camped about twelve miles north of Mt. Trumbull on the return route to Santa Fe. Hunger and extreme thirst had driven two of his men south to Indian villages (A.W.O.L.) in search of aid. They remained for two days. Nothing was recorded of their exploits, but it seems rather certain that they camped in the drainage of the Toroweap and viewed its panoramic splendor. That they made successful contacts with the Indians there is no question, for parties of the red men followed their white brethren back to the Escalante camp and traded some very welcome food consisting of prickly pear cake, grass seeds, pine nuts and small quantities of "wild goat meat" (probably mountain sheep or venison) for pieces of cloth and beads. Today on a protected, black lava cliff near the Witch's Pocket, a water hole and camp site of Indian fame (undoubtedly the nearest water that these men could have reached), may be seen a white cross, faded by decades of time. No one knows its origin, but it could have been placed there by these truant men of the Escalante party.

On September 16, 1870, J. W. Powell[3], the first man of science to visit the Grand Canyon National Monument, camped at the same water hole, The Witch's Pocket, located on the northeast slope of Mt. Trumbull. Although a year had elapsed since he had completed the first navigation of the Green and Colorado rivers, it was the lingering memories of a tragic episode that had occurred southwest of Mt. Trumbull during the last few days of this notable expedition that brought him to the Monument area. Three of his men, weary and hungry after weeks of battle with an uncharted, unyielding and savage torrent, and terrified over the probabilities of entrapment within the increasingly narrowing profiles of the canyon, abandoned the expedition. They were last seen trying to scale the seemingly impassible north wall of the inner gorge. Weeks later in the frontier settlement of St. George, Utah, Powell received meager reports of the massacre of these three men by the Shivwit Indians west of Mt. Trumbull. Another river expedition had been organized, and Powell was on his way to ascertain first hand from the Indians the details of this tragedy.

Of particular interest to the biologist are some of Powell's comments on the grass found growing in the vicinity of Mt. Trumbull where today there is utter impoverishment of all forage species. "At one o'clock we descended into a lovely valley, (at the steep base of Mt. Trumbull) with a carpet of waving grass . . .[2]" The principal Indian village was located at what is now called Nixon Spring, located on the south base of Mt. Trumbull. To reach it Powell crossed the west end of the mountain, ". . . over a divide between two rounded peaks. I send the party on to the village, and climb the peak to the left, riding my horse to the upper limits of the trees, and then tugging up afoot. From this point I can see the Indian village, too, in a grassy valley, enbosomed in the mountains, the smoke curling up from their fires; my men are turning out their horses, and a group of natives stand around.[2]"

The White Man's Toll

Grazing of the Arizona Strip was inconsequential until about 1880, but today no available segment of this great expanse of land, including the Grand Canyon National Monument, has escaped the ravages of livestock. Toroweap Valley, because of its abundant grassy plains of early days, its mild winter climate and its proximity to the permanently flowing springs of Mt. Trumbull was especially plundered by the herdsman. Within a decade after the Monument was established in 1932, the northern boundary that bisects Toroweap Valley was fenced, of course, in order to exclude these hordes of livestock from the accessible and scenically attractive rim country to the south. Fifteen years of carefully regulated grazing has produced remarkable recovery of the vegetation except on the most heavily abused grassland sites near the Monument entrance and on the sagebrush lands of the western valley slopes.

All of the pigmy forest of the Monument, including the Kanab Plateau and the area from the unfenced northern boundary to the jagged and irregular canyon brink, is currently stocked far beyond the grazing ca-

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WHIPPLE'S YUCCA makes a showy display of flowers in early April on the precipitous slopes of the inner gorge.

Progress Toward A Sound National Water Policy

• By **Richard D. Hoak, Ph.D.,** *(University of Pittsburgh)*
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Everyone, who understands our dependence on water, is concerned by the present condition of our water resources.

Every science teacher should realize the dependence of flood control, forest cover, navigation, agriculture and industry on our water resources, and what attempts are being made to formulate a national water policy.

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Development of policy governing water resources in this country has been piecemeal and makeshift. Decisions affecting this important public interest have generally been based upon immediate needs in particular areas. At a White House conference on natural resources in 1908, Theodore Roosevelt described the management of rivers as one of the prime examples of mismanagement over a century. The past half century has seen little change for the better. Despite vast expenditures for water projects by the Federal government, a national water policy has never been established by Congress.

It was the intention of the authors of the Constitution that it provide a flexible framework to be filled in by statutes and legal interpretations. The so-called Commerce Clause *(Art. I, Sect. 8)* states that "The Congress shall have power to regulate commerce with foreign nations, and among the several States, and with the Indian tribes." Rivers were highly important commercial arteries during our early history; indeed, they were a primary factor in the settlement of the western territories. The simply-worded Commerce Clause was an effective instrument for the purpose. It has been so elaborated by accretion of a very large number of statutes and legal precedents that it now encompasses almost every aspect of water use and conservation.

Federal, state and local expenditures for water resources projects now amount to something like billions of dollars annually, a rate some ten times greater than it was before 1930. An investment of this magnitude would seem to provide reason enough for agreement on a policy which would require coordination and overcome wasteful practices. Moreover, as multipurpose projects become more complex and the demand for available water steadily increases, a sound national policy becomes mandatory.

Although no broad water policy exists today, this is not to say that we are without policies. Decisions of the courts, implied or expressed policies in Federal legislation, and policies established by Federal bureaus, have resulted in a chaos of unsound and uncoordinated principles for managing water resources. There are 38 Federal Agencies which deal directly in some degree with the water resources field, but it would be fruitless to attempt to fix responsibility for the wasteful overlapping of functions of these agencies. They are largely bound by the actions of Congress, and neither political party is free from the practice of trading and responding to pressures when water projects, whether good or bad, come up for authorization. Nevertheless, certain agencies exert a powerful effect by promoting legislative provisions which enlarge their respective functions. The 10th Amendment states that, "The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively, or to the people." It is these reserved powers which Congress has been delegating little by little for a long time. In recent years, however, a militant public interest in water resources appears to be forcing adoption of a sound national policy.

Study of Water Resources

In 1947, at the suggestion of the American Society of Civil Engineers, Engineers Joint Council appointed an Exploratory Committee to report upon the feasibility of making a detailed study of water resources, and of implementing resulting recommendations with appropriate legislation. This committee reviewed the whole status of water resources developments and future needs. It submitted a report in 1949 which called attention to the existing confusion and lack of coordination, and concluded that a comprehensive study should be undertaken, preferably by a Congressional Commission. On the basis of this report, EJC transformed its temporary committee into the National Water Policy Panel and directed it to take suitable steps toward establishment of a sound policy.

On January 3, 1950, a temporary Water Resources Policy Commission was created by Executive Order No. 10095. This Commission invited individuals and organizations to submit their conceptions of the elements of a national water policy. EJC authorized its Panel to formulate and present specific water policy proposals to the President's Commission on behalf of EJC. Under this authorization, the Panel invited some 75 leading experts in the water resources development field to serve on voluntary task committees to prepare a statement of national Policy.

Basic Principles

Engineers Joint Council has consistently supported national water-policy principles which are inherently fair and unpredjudicial to all. Its Water Policy Panel

has decried that the use of biased benefit-cost ratios to justify unsound projects, and it has deplored proposals to achieve nebulous social gains at the expense of financial feasibility. The Panel's final report, "Principles of A Sound National Water Policy," emphasizes two fundamental axioms: (1) public money is limited in availability and (2) public needs, such as water, highways, schools, hospitals, etc., compete for public money. It therefore developed criteria which would distinguish "good" from "bad" undertakings. The basic principles of the Panel and its task groups are epitomized in the following quotation from its report.

"Conservation and control of the waters of the United States are in the national interest, but not necessarily a function of the Federal government. On the contrary, that which can be done by the individual should be done by him, and that which requires collective action should be done at the lowest governmental level practicable. The Federal government should engage in the conservation and control of waters only when the collective action of all the people is necessary for accomplishment of the objectives.

"Such collective action through the medium of the Federal government is justified for only two purposes:

"*First*, to do those things which are essential to the national defense or otherwise of substantial benefit to all the people throughout the nation; and

"*Second*, to aid in financing the cost of construction of works for the benefit of a limited number of people on terms equitable to all other citizens of the nation.

"In the discharge of the first function the Federal government is acting as a trustee in the disbursement of tax revenues on a non-reimbursable basis for the general benefit. It follows that such expenditures should be made for those purposes which will produce the greatest benefits to the nation as a whole. This responsibility goes far beyond any determination of feasibility; it requires a determination of what is best, not merely what is good.

"In its performance of the second function the Federal government is basically acting as a banker responsible for the soundness of his loans. It is fundamental to this function that such loans should be repaid as long as there is a national debt and that the period of amortization should not exceed the useful life of the works. It is also fundamental to this function that those who benefit directly from the construction of such works for the conservation and control of water should repay all costs properly allocable to the production of such benefits; furthermore, where indirect benefits will accrue to a region in greater degree than to the nation as a whole, the people in that region should repay a like proportion of all costs not allocable to direct benefits.

"All non-reimbursable expenditures and all subsidies, regardless of the source of payment, should be considered as being for the general benefit, and should be compared with the benefits which could be derived from the expenditure of like sums for any other purpose at any other location. Only such portions of the total cost as will be repaid with interest by beneficiaries can properly be excluded from this test of comparison."

Whereas, the EJC report recommends cooperative methods under our present form of representative government, the President's Water Resources Policy Commission proposed an entirely new system of government. It would establish River Basin Authorities which would be independent of local and State governments and which would take over much of the control now exercised by those governments. These authorities would have complete control over water uses, minerals, land uses, forests, power, and recreation within their areas. They would be controlled by commissioners and by a chairman, appointed by the President, who would not be responsible to the citizens of the area. Congress would confine itself to appropriating money recommended by the authorities for river basin development, and it would have no control over the manner of spending of such funds. Any payments by beneficiaries would have little relationship to the benefits that would accrue.

Financial vs. Economic Feasibility

There are a number of points of agreement between the two reports, but throughout the report of the President's Commission the emphasis is almost universally on Federal direction and control of basin planning. The Commission's report stresses social gains from multipurpose projects rather than financial returns. As social objectives generally cannot be measured in tangible terms which can be included in the costs of projects, the report presents no specific basis on which the feasibility of basin plans in whole or in part can be defined. What the Commission calls "financial feasibility" is illustrated by the statement "Financial feasibility is not the same as economic feasibility. Financial costs and returns should be considered in analysis, but financial feasibility should not alone determine the desirability of a program or policy. For this reason the Commission is recommending that Congress eliminate the requirement that irrigation projects show financial feasibiliity." Since many Federal irrigation projects have been very unsound financially, one wonders about the lengths to which such an expressed policy might be carried. There is a clue in the Commission's statement that "The Government has come to be recognized as an agency for social and economic action which need not follow the rules of the private capital market in order to obtain the necessary capital or to make investment decisions."

One cannot quarrel with the concept of government as an agency for promoting sound social gains. But one can disagree with an unreasoning faith in the efficacy of benign bureaus in deciding how those gains should be attained. There is something immoral in the practice of irrigating arid lands at excessive cost when immense humid and semihumid areas could be developed at a price farmers could afford.

The need for a uniform national water policy is apparent in every phase of water resources development, but it can best be illustrated by the practices of the Bureau of Reclamation. Arid lands have been brought into productive use by irrigation since ancient times. Large areas were irrigated in this country long before the white man came. Until the Reclamation Act

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Secularism in Modern Science

• By Mary Ann Foley, B.A.
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The use and misuse of the scientific method is one of the most discussed questions in the philosophy of science.

This article is the result of discussions held during a coordinating seminar with college seniors majoring in either biology or chemistry. It was presented by Miss Foley at an interdepartmental seminar at Anna Maria College.

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Secularism, as such, has no implications in the field of genuine science, that is, the empiriological sciences. According to Bishop Sheen, it is "the business of the scientist to pursue physical and chemical investigations[4]." It is not his privilege as a scientist to suggest any principle which would explain anything other than the measurable and the observable.

There is a pitfall, however, which has not been sufficiently avoided: the danger of philosophers and scientists impinging on one another's special territory. Philosophical ideas have, unwittingly or otherwise, been intermingled with scientific theories. If the scientific theories were plausible, there was a tendency to accept not only these theories but also the philosophical concepts that accompanied them.

Thus did secularism enter the field of the experimental sciences. It is necessary to define secularism as understood in its relations to these sciences. The principal tenet, deriving from Kant and Comte, holds that all knowledge beyond the experimental is impossible, "that the search for truth is vain and illusory, and that there is no higher discipline to interpret the conclusions of science than the experimental verification[4]."

According to this tenet, experimentation becomes the norm of reality. What is real is concrete and can be known only by special experience, that is, by the scientific method[7]. Thus the use of reason beyond experiment is null and void and nothing but the phenomena offered to the external senses has any value in so far as knowledge is concerned.

It is difficult for us to conceive that men can be so blind to the reality of speculative knowledge. However, testimonies are available to show that mental attitude of some scientists. In an article on *Science and the Supernatural*, A. J. Carlson states the following:

> "As I see it, the supernatural has no support in science, it is incompatible with science, it is frequently an active foe of science." *(Ref. 2, p. 95.)*

In the words of V. E. Smith, professor of philosophy at Notre Dame University,

> "The so-called scientific method has been turned into the ritual of a new modern religion called secularism, and the credentials of that method have been put beyond debate." *(Ref. 5, p. 192.)*

Secularism has placed science before mankind as the infallible dictator of the validity of all man's reasoning processes. Freud has extended the empiriological method to psychology, Comte to sociology, Russell to metaphysics, the Marxians to economics, and Dewey to Education.

> "Thus, John Dewey, who has left his mark upon a whole generation of present American thinking, merely copies the method of physics into a philosophy . . . Picasso, the painter, was influenced by Einstein's theory of dimensionality." *(Ref. 5, p. 6.)*

The use of the scientific method in fields where it is not valid is generally termed *scientism*. Scientism, an aspect of secularism, takes empiriological fact to be philosophical principle. It is convinced that philosophy can be of value only if it adopts the method of some branch of experimental science[7].

It is my purpose to show the validity of the scientific method when applied to its proper object and then to point out reasons why the scientific method is not suited to a deeper study of reality—a study that goes beyond the measurable and the observable.

In the first place, I wish to state that the scientific method is perfectly valid when applied to its proper object, the measurable and the observable. It is, in fact, the only possible approach to matter, in so far as matter is quantified. In the first degree of abstraction the scientific method studies particulars, assembles observable facts, and then abstracts from these a generality which is termed a law of nature. The scientist then seeks to express this law of nature in terms that are applicable to other circumstances. To this end, he rises to the second degree of abstraction and divests matter of anything which is not quantity and expresses his findings in a mathematical equation[6]. So far, the scientist is in his proper territory and is perfectly justified. The method which he has applied is valuable and is characterized by objectivity in the measurements and observations which he has made. Objectivity is one of the qualities of the intellect which should be developed by a serious application to the empiriological sciences. The need for this quality justifies the insertion of the physical, chemical or biological sciences in the curriculum of a liberal arts college.

Limitations of the Scientific Method

But the scientific method has its limitations. It cannot be used, nor are its conclusions valid, beyond the realm of its proper object. Its limitations arise from four characteristics: it is based on experiment, not experience; it deals with the inert; it pursues things only

in so far as they are passive; it equates cause and effect in its mathematical equations[6].

I shall now consider the first point: the scientific method is based on experiment, not experience. It is necessary here to compare experience with experiment. Experience is more realistic than experiment, it comes before experiment. The philosopher uses experience as the backbone of his conclusions. The scientist, on the other hand, relies almost entirely on experiment. An experience which is deliberately controlled may be termed an experiment. It is precisely because of this element of control that experiment always interferes in some degree with what it observes. The second differentiating characteristic of experiment is that it recognizes only those things which can be measured and counted as having any value[5]. Naturally, both experiment and selectivity are absolutely necessary to science if any facts are to be discovered. This, however, should not rule out experience as a valid philosophical tool, as the secularism of the modern world would have us do.

The second point to be examined concerns the fundamental association between the scientific method and inertia. The sphere of modern physics was first blueprinted by Galileo and Newton when they formulated laws to express reality in terms of inertia. These laws, as applied in physics, have been of invaluable assistance in helping the physicist understand nature. However, when these laws are carried to the completion of their meaning, and applied outside of science, it becomes evident that nothing has a reality of its own. The notion of inertia, according to Vincent E. Smith;

> ". . . thins a material thing into an indifferent state, depending for its reality wholly on the transeunt forces acting from the outside of it. According to the empiriological method, the action of an atom is exactly equivalent to its component parts and how they act, and the subatomic particles in their turn owe what they are and do entirely to extrinsic forces as well." *(Ref. 6, p. 28.)*

Another characteristic of the empiriological scientist is that in his work he considers nature only in so far as it is passive. According to scholastic philosophy, the object acted upon has a say in the way in which it will react to a given stimulus, that is, it has a nature of its own which always reacts in a certain way to definite external circumstances. Modern physics denies that matter has such qualities as nature or substance. Things are considered as passive and completely dependent on external forces[5]. If we accept this, and apply it outside of physics, we must necessarily conclude that matter is basically indetermined. Radioactivity is often offered as a proof of the indetermination of matter. In considering a piece of radium, for example, the physicist can say with great accuracy that within 1,590 years one half of the atoms in the radium will have disintegrated. He cannot, however, predict which atoms will disintegrate. For this reason some scientists conclude that the atoms are indeterminate and disintegrate at random for no cause whatsoever. Such scientists fail to realize that the failure of measurements or of observations does not mean that the individual atoms are essentially indeterminate. The atom does have a nature which causes it to react in a definite manner in response to external factors.

Finally, the scientific method equates cause and effect. Referring again to Newton's laws, we can sum them up in his third law which states that for every action there is an equal and opposite reaction. For example, when a man walks down a street there are two forces at work at the spot where his foot presently rests. The first force is that with which he pushes down on the ground and the second is the force with which the ground pushes up on him. In other words, the effect is equal to the cause. Another example of this equating of cause and effect is given by Max Born in his book on the *Natural Philosophy of Cause and Chance*, in which two stars are, by means of gravitational attraction, rotating around each other and are therefore the "cause" and "effect" of each other[1].

Thus we find that mathematics, that science which considers only quantity, has taken a major position in the framework of modern science. It is in fact considered by some to be the very image of reality. This tendency to consider mathematics as the science of matter was inaugurated by Descartes who first identified quantity with the substance of material things[5]. Sir James Jeans reiterates this cry in his book *The Mysterious Universe*, when he says; "From the intrinsic evidence of His creation, the Great Architect of the universe now begins to appear as a pure mathematician." (3, p. 4.) Mathematics expresses observations of the scientist in equations and in this way identifies unlike things. For example, in Einstein's law of conservation of mass-energy $E = mc^2$, energy is the cause of matter, matter is the cause of energy. Thus, cause and effect are once more equated. If such equations are turned into a philosophy, as the modern advocates of secularism would have it, this world and everything in it would become totally passive, inert and potential. Thus we see that the empiriological world is an equalitarian one. In such a world things have nothing of their own, they are equated to something else.

Fallacy of Scientism

In presenting these limitations to the empiriological method it is not my intention to cast aspersions on science or on its method but merely to ascertain its place in the modern world as an instrument for uncovering the secrets of the physical world and not as a philosophical instrument. Furthermore, it must be emphasized that the scientist is also a man and as such necessarily thinks and judges in a philosophical fashion and thus never reaches pure method.

Philosophies such as Secularism try to apply the scientific method to all knowledge and conclude that things that science can not prove are not real. They fail to realize that we can never reach complete truth by studying passivities alone. The realization that there is more than one avenue to truth escapes them completely. Scientism, that particular brand of Secularism which holds that the only valid knowledge is that which

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Acids, Bases and Purple Cabbage

• By Dorothy Alfke, Ph.D., *(Cornell University)*
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Has our science teaching become too dependent on complicated apparatus and commercially prepared materials?

Do we make opportunity to relate our science teaching to every day experiences of our students?

Here is an interesting article on the use of a familiar vegetable to demonstrate the difficult concept of acids and bases.

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As with so much of our science teaching, with a little imagination we can make any treatment of a topic involving indicators or acids and bases more fun for our students and more closely related to some every day experiences.

Litmus paper is fine but limited in its range. Soil testing kits cost money but are quite accurate. Phenolphthalein is a substance exhibiting a fine sudden change and is therefore excellent for titration. Indicators such as we use in bacteriology studies are tricky to work with and are rarely found in our secondary school supply cabinets. All these and more are the substances of scientific research and many have their place in our teaching. However, we have in red cabbage an indicator which offers many possibilities for enriching learning with greater reality. It can be used as a substitute or supplementary indicator, in our teaching of biology, chemistry or general science when acidity and alkalinity are under discussion.

A head of purple cabbage can be shredded and heated in water until the water turns a deep purple color. This water can be poured off into a jar, more water added to the cabbage, and again heated. This is repeated until several quarts of juice, which can be used as an indicator, are obtained. If refrigerated both juice and cabbage will last for several months. Canned red cabbage can be used when the fresh cabbage is not available. It may be advisable to dilute the juice to make color changes more readily visible.

Pieces of paper towel or filter paper can be saturated with the juice and dried. If this is done several times to the same piece of paper, it can be cut into strips and used in the same manner as litmus paper.

Perhaps a teacher would like to draw on the experiences of the youngsters to initiate the investigation. Most people who have ever had red cabbage, cooked or raw, will recall that vinegar is often used for flavor and when it is added, the purple color changes to red. Only the observant or curious will have noticed that when dishes or pots and pans which contained red cabbage are washed, the dishwater turns green in response to the alkaline soap. The substance in the cabbage responsible for these changes in anthocyanin, which is also present in many other plants.

Some Ways in Which the Juice May Be Used

a. The reaction of the juice to acids can be established by adding a few drops of hydrocloric acid to some juice in a glass or test tube. A change to red will result. Similarly, a few drops of sodium hydroxide can be used to indicate the reaction to a base. This will produce a change to blue and in most cases, greater alkalinity will produce a green color. With the test established, the students can experiment with other substances and they should be encouraged to investigate unknowns of their own selection. A few suggestions might include fresh milk, sour milk, fruit juices, soaps, tap water, aquarium water, various antiseptics and cleaning agents. In some cases it might be more satisfactory to add the cabbage leaves or a concentrated juice solution to the substance being tested in order to obtain easily observed results.

b. The range of red cabbage juice as an indicator might be explored. If an acid is added drop by drop, stirring after each drop, a series of changes will be observed. When no further color change results from the addition of more acid, the limit of ability of the juice to show degree of acidity has been reached, that is the bottom of its ph range. If a basic solution is now added, drop by drop the color change will reverse itself, pass back to purple, then to blue and usually on to green indicating the top of the ph range. If appropriate, a discussion may follow of the function of the range of an indicator in such areas as soil testing, bacteriological work and titration.

c. Some soil testing can be carried out. A series of jars of juice of the same dilution can be lined up. One jar should be left unchanged for a control. About a tablespoonful of soil from various locations can be added to each of the other jars and the contents shaken or stirred. After settling, the colors of the liquid portions can be compared and some indication of the acidity, alkalinity or neutrality of the soils tested can be obtained. Soils can be tested before and after fertilizers have been applied. Water solutions of the fertilizer might also be tested before the fertilizers are applied to the soils.

d. In an area where limestone rock is prevalent, streamwaters can be tested with cabbage juice to discover some clues to the drainage area of the stream. Similarly if a bog can be located this water might be tested with cabbage juice. It might be fun for students to test samples of various natural bodies of water and do some intelligent guessing as to causes of results

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Detergent Builders and Additives

• By Max C. Metziger *and* J. V. Karabinos
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Soaps and detergents when used in various household or commercial applications are usually blended with a variety of inorganic and organic compounds. The role which each of these builders and additives plays in cleaning processes is described in this paper.

This paper is an abstract of a talk presented by M. C. Metziger to the Klenzade Educational Seminar, French Lick, Indiana, on March 24, 1955.

M. C. Metziger is Director of Research and Development and J. V. Karabinos is Director of Organic Research at the Blockson Chemical Company.

Detergency in the broadest sense simply means cleaning. However, the more common usage of this term implies that in the cleaning process physiochemical action is involved. Of primary importance are the effects of interfacial energy, electrical charge and adhesion. The total detersive effect depends largely on five variables, namely the composition of the soil and bath, the nature of the surface to be cleaned as well as the conditions of washing and concentration of the detergents and builders. This paper will be concerned with the functions of the various builders in detergent compositions.

General Considerations

In general, builders have a two-fold effect upon the bath, that is the maintenance and control of alkalinity to prevent hydrolysis of soaps and the softening action of the builder on the water. For example, the pH at which soap gives the greatest detergency under simulated laundering conditions is in the neighborhood of 10.5 to 11. Mixtures of builders, such as trisodium phosphate, sodium carbonate, sodium sesquicarbonate and sodium metasilicate even in dilute solutions, maintain the desired alkalinity and thereby improve the performance of soaps or detergents. In connection with softening action, builders, such as trisodium phosphate, simply remove calcium and magnesium ions from hard water by precipitation. However, the complex polyphosphates tend to sequester these ions and to prevent their adverse action upon soaps or detergents. These complex phosphate and silicate builders can act by modifying the adsorption of the detergent on the surface to be cleaned or on the soil itself

The polyphosphates and colloidal agents such as carboxymethylcellulose also behave as soil-suspending or peptizing agents. Finally, the inorganic type builders apparently have some effect on interfacial energy relationships at the surface, soil and bath phase boundaries. Even sodium chloride and sodium sulfate markedly affect the surface and interfacial tensions of most surface-active agents and prove to be beneficial to detergency when present in small concentration.

It should also be mentioned that preferential wetting of the surface to be cleaned is important to the detersive process particularly for the removal of the final layer of dirt from the surface. Polyphosphates and carboxymethylcellulose are quite effective, in this connection, when cotton fabrics are cleaned.

It is well known that detergent molecules in dilute solutions associate to form colloidal agglomerates of high molecular weight. These are generally referred to as micelles and have a direct bearing on the performance of a detergent. Builders are known to favorably affect the formation and possible structure of micelles and reduce the critical concentration for micelle formation.

Besides those substances which actually increase detergency a number of additives are blended into cleaning compounds for such purposes as corrosion inhibition, foam stabilization and to increase viscosity. The various builders and additives are usually classified according to their inorganic or organic constitution. They are considered herein accordingly.

Inorganic Builders

Silicates—The primary function of silicates in detergent mixtures is to form protective coatings on certain soft metals such as aluminum, copper, zinc and tin, in order to reduce the corrosion effect of alkalies on these metals. For this purpose, the low alkalinity silicates are most effective and are extensively used in spray-dried household detergents. The higher alkalinity silicates are most commonly used in industrial specialty cleaners.

The following silicates are commercially available:
Sodium orthosilicate $2Na_2O:1SiO_2$
Sodium sesquisilicate $3Na_2O:2SiO_2$
Sodium metasilicate $1Na_2O:1SiO_2$

Liquid silicates, so-called waterglass, of various ratios Na_2O to SiO_2 such as:

$1Na_2O:3.22SiO_2$ $1Na_2O:2.5SiO_2$ $1Na_2O:2SiO_2$

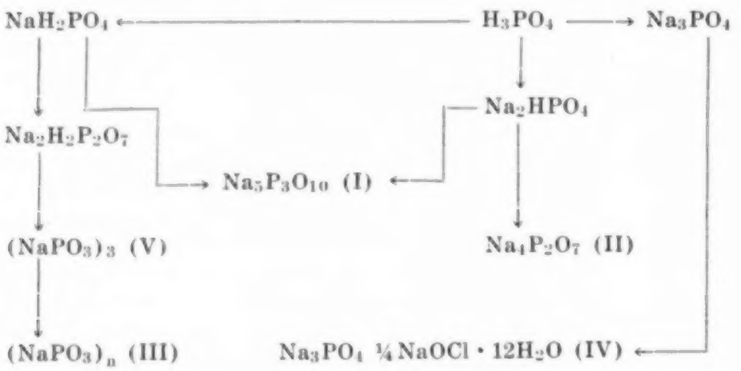
Carbonates—Carbonates are extensively used as ingredients in industrial and household cleaning compounds, sodium carbonate (soda ash) to supply economical reserve alkalinity, and sodium sesquicarbonate, modified sodas and bicarbonate to reduce harmful effect of other highly alkaline ingredients. They are not commonly used in spray-dried household products.

Hydroxides—Sodium hydroxide (caustic soda) is used in metal cleaners and other heavy-duty cleaning operations.

Borates—Sodium borates, for example Borax, because of their mild alkalinity, find limited use in household cleaning compounds. Sodium perborate is used as a mild bleach and in destaining of plastic dishes.

Phosphates—By far the most widely used builders in synthetic detergent mixtures and other cleaning compounds are the sodium phosphates and particularly condensed or molecularly dehydrated phosphates.

The following figure illustrates the chemical relationship between the various phosphates.



The complex phosphates of commercial importance are sodium tripolyphosphate (I), tetrasodium pyrophosphate (II) and sodium polyphosphate glasses (III).

Tetrasodium pyrophosphate is obtained by dehydrating two molecules of disodium phosphate while sodium tripolyphosphate is produced by dehydrating 1 molecule of monosodium and 2 molecules of disodium phosphate.

Sodium trimetaphosphate (V), made by heating monosodium phosphate, does not have sequestering properties presumably because of its ring structure but is readily hydrolyzed to tripolyphosphate by treating its aqueous solution with alkalies.

The polyphosphate glasses are produced by rapidly chilling a melt with the desired sodium oxide to phosphorous pentoxide ratio. Glasses are obtained up to a ratio of 1.4 Na_2O to 1 P_2O_5. Above this ratio it becomes difficult to obtain a clear glass because of the formation of tetrasodium pyrophosphate crystals.

Sodium tripolyphosphate has had a phenomenal growth starting about 1945. This parallels directly the growth of the heavy duty synthetic detergents. In 1953 468,000 tons of "Tripoly" was produced, the major portion of which was consumed by the synthetic detergent industry.

One relatively old member of the phosphate family which has come into the chemical limelight in recent years is chlorinated trisodium phosphate (IV). This is a complex or double salt of trisodium phosphate and sodium hypochlorite. It is one of a series of double salts of trisodium phosphate and a monovalent compound such as sodium hydroxide, nitrate, borate, manganate and chloride. Up to recently, it was used only as a disinfecting and sanitizing compound. It now finds its principal use in dishwashing compounds where it prevents water spotting of glasses and aids in preventing or removing stains from plastic dishes.

A combination of properties makes the complex phosphates useful as builders. The most important of these properties may be enumerated as follows:

1. Sequestration
2. Inhibition or threshhold treatment
3. Defloculation or dispersion
4. Corrosion control
5. Synergism

1. Sequestration—The ability of the complex phosphates to sequester alkaline earth metals by forming soluble undissociated complexes is one of the most significant properties of those compounds. There are numerous methods for measuring the complex-forming ability. The results vary considerably because they depend on a number of factors such as pH, temperature, concentration and especially the presence of other anions that tend to compete with the calcium and magnesium ions. Of the alkalies commonly used in detergent mixtures trisodium phosphate tends to decrease and silicates tend to increase the sequestration value of the polyphosphates.

In built synthetic detergents, sequestration is useful in preventing accumulation of calcium, deposits over several washing cycles and especially in diminishing precipitation during the rinse cycle.

2. Inhibition or Threshhold Treatment—Threshhold treatment involves the addition to hard water of a few parts per million of complex phosphates which inhibits the precipitation of the hardness elements when subjected to conditions favoring precipitation. This property is useful mainly in the water treatment art when water is used for cooling in condensers and other heat transfer equipment. It is probably of no significance in building of detergents..

3. Deflocculation and Dispersion—The ability of the complex phosphates to deflocculate or peptize and keep in suspension a number of insoluble inorganic materials is of great interest to a number of industries. It is used in purifying clay where the suspension of the fine clay particles allows separation of the heavier impurities. In oil well drilling, it is used to control viscosity of the bentonite in the drilling muds which allows easy removal of the cuttings from the rotary drills and separation of the heavy cuttings from the drilling mud. It is also of great importance in the detergent field, where it keeps dirt particles in suspension and aids in preventing redeposition on the washed cloth.

4. Corrosion Control—In waters that are normally corrosive to iron, treatment with a few parts per million of complex phosphates has a tendency to form a film on the iron surface and prevent further corrosion. This property is useful mainly for municipal and industrial water treatment and is of no value in detergent formulation.

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Recent Advances in the Study of Micro-Morphology

• **By Benjamin M. Siegel**
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The electron microscope and its associated techniques have revealed many new facts concerning the microstructure of the animal and plant world.

Professor Siegel discusses some of the recent advances in the study of micro-morphology, especially those relating to viruses.

This article contains much up-to-date information not readily available to teachers of high school science.

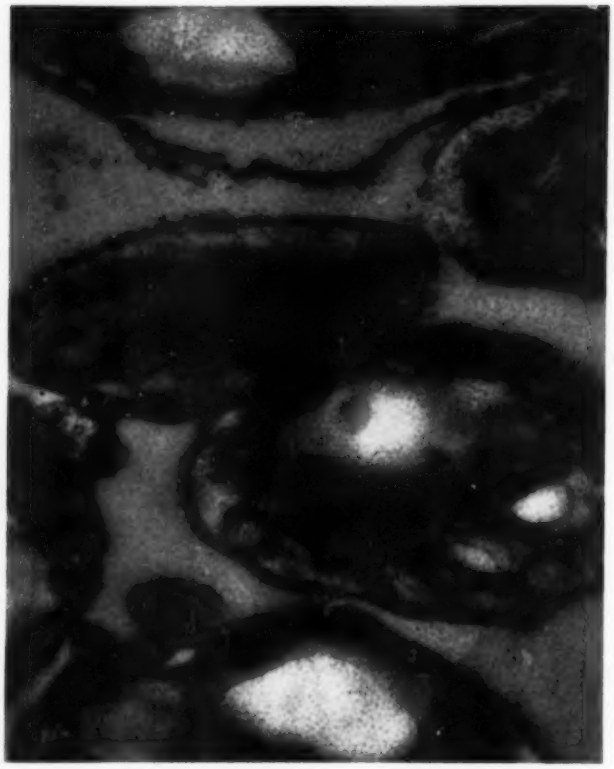
Vision has always been man's most powerful sense. While we have become aware of the illusions possible, sight is the only sense which transmits such an enormous amount of simultaneous and continuous information to our brain. When we wish to observe structural details and complex inter-relationships in nature we must rely upon our sense of vision. The extensions of man's range of vision, first into the vast distances of the heavens with the telescope, and then with the light microscope into the microscopic world, have been the principal means by which we have enhanced our understanding and appreciation of the magnitude and subtle complexity of our universe and the living creatures in it.

The ultimate resolution of the light microscope is limited by the wavelength of light and the refractive index of glass lenses to slightly better than 2,000 Angstroms for visible light and 1,000 Angstroms for ultraviolet radiation. Fundamental advances in our physical knowledge laid the basis for the electron microscope. Some thirty years ago the wave nature of the electron was established by the first electron diffraction experiments and the basic principle of producing electron lenses with electrostatic or magnetic fields possessing axial symmetry was established. Within a decade the first electron microscopes were constructed which enabled man to extend his range of vision beyond that given by the light microscope and into the collodial world. The ensuing years have seen this instrument perfected until today resolutions of 5 to 6 Angstroms have been demonstrated, approaching experimentally the limit of resolving power predicted by theory. Today with hundreds of commercially built instruments being used in laboratories all over the world, a competent worker can achieve working resolutions somewhere between 10 to 20 Angstroms, giving him a useful magnification of 100,000 to 200,000 times. Thus, our range of vision has been extended a hundred-fold beyond the range of the light microscope.

Workers in many fields have applied this new instrument to their special problems and in the early years it was exciting to explore this new world of submicroscopic particulate matter. New complexities in structure were discovered, ambiguities in measurements obtained by indirect means were resolved, and conflicts in various hypotheses concerning submicroscopic structure were settled by direct observation. But it is only within the past few years that adequate techniques have been developed which make it possible to apply the electron microscope in a systematic way to a wide and significant range of problems. The first techniques available to the electron microscopist for specimen preparation were primitive. Only after years of searching and the application of considerable ingenuity was it possible to extend observations beyond the examination of particulate matter, below the surface of solids, and into the complex microstructure of the tissues that make up our plant and animal world.

This significant advance was made possible by the development of highly refined methods for cutting

OBSERVATIONS ON SURFACES of solids with the electron microscope are made on replicas of the surface. Several new refinements in technique have been developed in recent years. This electron micrograph is of a replica from a cleavage face of a specially treated potassium chloride crystal. The replica was made by first shadowing the cleaved crystal surface with uranium and then depositing a layer of silicon monoxide on the surface to produce the substrate for the replica. Magnification 30,000X.

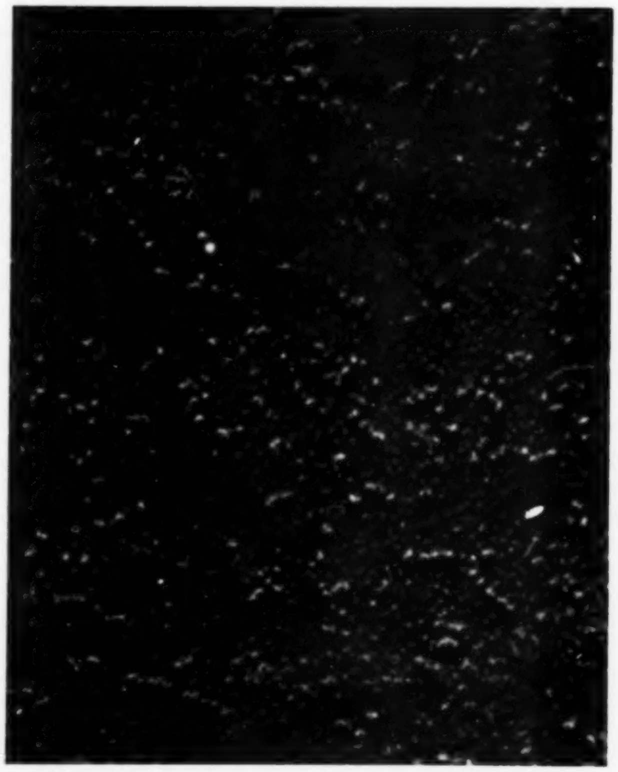


SECTION FROM TOBACCO leaf showing chloroplasts in which the fine lamellar structure of the grana is apparent. Magnification 20,000X.

ultra-thin sections of tissues and examining them in the electron microscope. Here full advantage can be taken of the instrument as a microscope. It is only with this type of observation that we can examine the inter-relation of heterogeneous structures and their organization. There are several indirect methods of observing the size and shape of particulate matter of colloidal and macromolecular dimensions, but these methods are not in general applicable to the study of the morphological detail of structures. Sedimentation and diffusion measurements using the ultra-centrifuge, light scattering, flow birefringence, and low angle x-ray scattering are some of the methods used to give very valuable data concerning the average size and shape of large aggregates of particulate matter and periodic structures. The electron microscope has also proven itself a valuable tool in studies of particulate matter and has done much to correlate and corroborate the data obtained by these indirect averaging methods. With the electron microscope a direct observation is made on a relatively small sample and thus it measures the sizes of the individual particles and records their morphological detail. It is true that the answer the chemist or physicist often wants is the average particle size and the particle size distribution of a large number of particles and if the electron microscope is used to obtain these data, a long and perhaps tedious job is necessary. But only the electron microscope can observe the detailed structure of these small particles and it is just such detail of sub-structure that has led to many interesting developments.

In virus study the morphological details of the virus particle have been found to be highly significant. Several indirect methods have been used successfully to characterize the size and general shape of viruses. But it remained for the electron microscope to show that the virus which attack bacteria, the bacteriophage, often have tadpole like shapes and that attachment to the host cell is by the end of this "tail" like structure. In collaboration with other techniques it has been possible to show that these bacteriophage actually have protein envelopes filled with nucleic acid and that it is only the nucleic acid which enters the host cell and "infects." And now this detailing of the structure of the virus has been extended to the rod shaped plant virus, tobacco mosaic virus. Electron microscope observations together with biochemical studies show that this virus is made up of a hollow rod of protein with long filaments of nucleic acid in the core of the rod, for with enzymatic digestion of the outer protein an axial bundle of filaments of nucleic acid is revealed by the electron micrographs of this carefully treated specimen.

Perhaps while discussing virus studies, mention should be made of a recently developed application of the electron microscope which does not concern itself directly with studying morphological detail. Methods for using the electron microscope in assaying the con-



A MOLECULAR DISPERSION of fibrinogen. Hydrodynamic measurements indicate that the molecule is 560A° in length with an axial ratio of 5:1. The electron microscope reveals that the dehydrated molecule is a nodular filament. Shadowed with uranium. Magnification 100,000X.

centration of small particles in liquid suspension have been established and they have introduced a quantitative aspect into electron microscopy which should be of continuing importance in many fields. These methods already find an important place in the work of virologists. One of the most successful methods is the "spray droplet" technique. Here an aliquot portion, of an unknown concentration of the virus to be assayed, is mixed with a standardized suspension of polystyrene latex particles. The mixture is sprayed from a nebulizer onto the specimen screen in minute droplets which are some 5 to 10 microns in diameter and electron micrographs of a number of these droplets are made for each sample to be assayed. By counting the number of uniform spherical particles of polystyrene to the number of virus particles in each droplet, a ratio is obtained from which the virus concentration can be calculated once the concentration of the polystyrene particles has been standardized. This number count on virus particles gives invaluable additional data which can be correlated with serological and infectivity titres.

But let us return to that exciting topic the study of the complex organization of tissue. Eight years ago reports appeared in the literature on the first successful modifications of a convential microtome so that embedded tissue could be sectioned thin enough for examination with the electron microscope. Since then a steady advance has been made until today, investigators in many fields of biology are preparing sections of plant and animal tissue, some as thin as 20 to 30 millimicrons, or the order of 1/20th the wavelength of visible light. With the art perfected to this degree details in cells have been resolved down in the 25 Å range and observations are now being made on the macromolecular structure of biological materials. Thus, whole new, basic studies have been opened up in such areas as cytology, histology and physiology. The architecture of cells can now be determined from the large molecules which form the basic building blocks of the whole cell. The fine details in cell membranes which are so important in the physiological process can now be delineated. In the substructure of the mitochondria, the sites of enzyme synthesis can be observed, and some investigators are already studying the location and effects, in the cells, of invading infectious agents such as virus.

The impression may have been created that all that remains to be done is to observe more and more structures until all are completely detailed. But there are still some serious problems of technique to be solved, and, more important, one feels that there are some fundamental limitations which are inherent in the restrictions that the electron microscope places on the specimens which can be used in it and the treatment they must undergo before they can be used. The most successful methods used at the present time for preparing tissue for ultra thin sectioning start with the fixation of 1 mm cubes of the plant or animal tissue in a buffred osmium tetraoxide solution. The standard method of dehydration in a series of increasing concentrations of alcohol is used, and finally the tissue is impregnated with butyl methacrylate monomer which is then polymerized either with catalyst at 45°C or by ultra-violet irradiation. This process embeds the tissue in a suitable matrix for sectioning on one of the several special microtomes which have been developed. Fractured glass, specially sharpened razor blades, or even the polished edge of a diamond are being used for the cutting knives. The present microtomes are designed so that the specimen block makes only a single pass by the knife for each section cut with the advancement between cuts accomplished, in most cases, by the thermal expansion of the specimen support rod. Each section is floated off, as it is cut, into a trough containing water or water with a small amount of some agent such as acetone to lower surface tension. By trimming the blocks of embedded tissue to give sections only a few tenths of a millimeter on a side, thicknesses as low as 200 to 300 Å have been obtained.

This brief description fairly well defines the present limits of the art of ultra-microtomy. Only the crudest beginnings have been made on methods of selective staining of structure and a great deal more experience will be needed before we can evaluate the effects of

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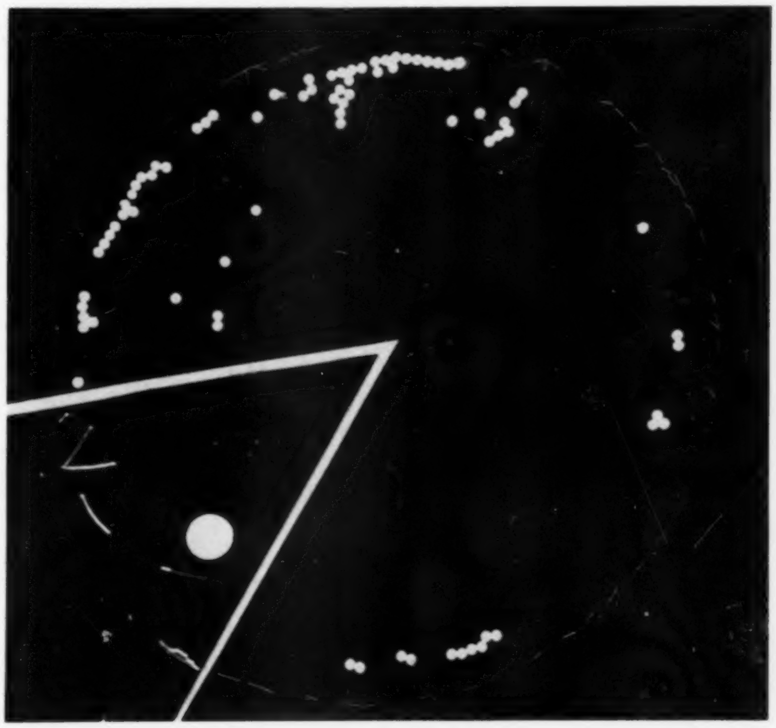

SPRAY DROPLET from an assay of tobacco mosaic virus. Shadowed with uranium. Magnification 5000X, insert 25,000X.

The Story of Stained Glass

• By Bernard O. Gruenke
CONRAD SCHMITT STUDIOS, MILWAUKEE, WISCONSIN

In recent years stained glass has regained the high place it formerly enjoyed among the architectural arts.

This article describes the production of ordinary stained glass and the thicker and richer stained glass, known as slab or chipped glass.

The making of stained glass windows is an art which belongs wholly to the Christian Era. Its traditions do not extend back beyond the great times of Gothic Architecture, and it is to this age that we turn to learn its basic principles.

The color effects, which are the glory of the art, are not directly produced by painting—the window is built up of a multitude of small pieces of white and colored glass, held together by strips of lead. The glass is colored when made, and the artist chooses the exact shades he needs, cuts them to shape, and fits them together to form his design. The irregularities in color and texture of the glass add to the richness and beauty of the windows.

Glass is made by fusing together some form of silica as sand, an alkali as potash, and some other base, as lime or lead oxide. All colored glass is "stained" or colored while in the molten state by the admixture of various substances; gold for ruby, cobalt for blues, chromium and iron oxide for greens, and so forth. The color depends on the exact composition of the glass and the temperature to which it is subjected, as well as the coloring matter used.

The steps in the production of stained glass windows are briefly as follows:

The making of the design comes first. It is usually a small-scale study of the opening, to convey an impression of the color and light effect that is intended. A full-size drawing in black and white, called the cartoon, is then prepared. From the cartoon the cutline and pattern drawings are made.

The cutline drawing is a careful, exact tracing of the leadlines of the cartoon on heavy paper. These are the outlines of the shapes for patterns to which the glass is to be cut.

The pattern-drawing, usually on heavy paper, is a carbon copy of the cutline drawing. It is cut along the black or leadlines with double bladed scissors, which, simultaneously cut away a narrow strip of paper, thus allowing sufficient space for the core of the grooved lead. This core is the supporting wall between the upper and lower flanges of the lead, and is shaped like a miniature girder, or like the letter "H" lying on its side.

The glass is carefully selected as to color and texture, the glass cutter places the pattern on a piece of the desired color, and with a steel or diamond wheel cuts the glass to the shape of the pattern.

After this the painter takes over. The main outlines of the cartoon are traced on the glass with an easily vitrifiable paint (iron oxide). The paint serves only to outline significant form and detail and to control light. Further patterning is applied in halftone mats to control the light and to bring all colors into closer harmony.

The painting is done while the glass is up in the light, held in place on a plate-glass easel by means of beeswax. In this way the painter approximates the conditions in which the window will eventually be viewed.

These pieces are fired in a kiln to fuse the paint and then the glass is ready for the glazier.

The cutline drawing is spread on the glazier's bench and laths are nailed down along two edges of the drawing to form the outline. Long strips of wide lead are placed along the inside of the laths. The piece of glass belonging on the edge is fitted into the grooved lead. A strip of narrow lead is fitted around the exposed edge or edges and the next required segment slipped into the groove on the other side of the narrow lead. This is continued until each piece has been inserted into the leads in its proper place.

The many joints formed by the leading are soldered, and the entire window is cemented on both sides to make it firm and water tight. The windows are made in sections of a size convenient for one man to handle. When the windows are installed they are secured with reinforcing bars.

The craft of stained glass is a serious and learned art, the craftsmen and designers are skilled technicians and artists. No other craft deals in light as brilliant and elemental. Color is of the first consideration.

Slab Glass

Another method of stained glass is called slab or chipped glass. Glass for this purpose is molded to a thickness of an inch or more. It is cut to the desired shape with chisels and diamond wheels. It may be chipped in such a manner as to deflect and reflect the rays of light as they come through the glass. The thickness of the glass and the chipping result in richer, deeper and more varied colors than can be obtained with thinner glass. Instead of the customary leads, cement is used in varied widths, as due to the brilliancy of the glass a greater separation (more black) is preferable for both color control and structural unity.

The resistance of the material is great enough to force a simplification of design and to discourage the

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Modification of Clouds and Rain By Artificial Cloud Nucleation

• By Louis J. Battan, Ph.D., (University of Chicago)
DEPARTMENT OF METEOROLOGY, UNIVERSITY OF CHICAGO

The modern rainmaker seeks to modify weather by techniques popularly called cloud seeding.

Can such techniques cause significant changes in weather?

The author outlines the present status of our knowledge, and points out the difficulties encountered in the evaluation of data obtained from cloud nucleation studies.

Although there is still a great deal of disagreement about the efficacy of cloud seeding, or artificial cloud nucleation as it is more properly called, as a means of increasing rainfall, scientists conducting research in this field have obtained sufficient information to permit conclusions regarding certain aspects of the problem. It has been definitely established that when particular types of clouds are considered, one can modify the natural growth and dissipation processes by seeding with particular kinds of substances. There is strong evidence which indicates that under certain conditions, the rain formation process can be initiated by cloud seeding. However, there is still considerable debate among meteorologists as to how much one can increase the amount of rainfall reaching the ground. Although it appears that under certain conditions the amount of rain which will fall in a particular area might be increased, the lack of experiments conducted under controlled conditions prohibits a definitive statement at this time.

Natural Processes of Cloud and Rain Formation

Before going into detail on the questions raised in the preceding paragraph, it is well to briefly review the processes by which clouds and rain are formed. It has long been known that a cloud droplet is produced by the condensation of water vapor on small particles in the atmosphere when the relative humidity is increased towards saturation. The increase in humidity is usually a result of the vertical displacement of air to levels of lower pressure. When the relative humidity reaches values close to 70 per cent, condensation begins taking place on these particles (condensation nuclei) which are hygroscopic and thus have an affinity for water vapor. When sufficient droplets have been formed to be seen by the naked eye, a cloud is said to have formed. Initially, the rate of growth of cloud droplets is rapid; however, by the time their diameters reach an average size of the order of 10 microns (one micron is equal to one millionth of a meter), the rate has decreased considerably. At this time the concentration of droplets is usually of the order of perhaps 200 per cubic centimeter. Many clouds persist in this condition for hours or even days without producing rain because the droplets are small, have a very low fall velocity and evaporate before they reach the ground. In rain, the drops have diameters of the order of 1000 microns and concentrations of the order of 200 per cubic meter. It is to be noted that considering the mass of water, about one million cloud droplets are needed to form one rain drop.

In order for a cloud to produce rain, a process which is more rapid than condensation (at drop diameters greater than 50 microns) must be present before precipitation starts. It has been found that the combination of the collision of droplets because of differences in vertical velocity, and their subsequent coalescence provide a means for rapid droplet growth. Theoretical and laboratory work have shown that a large drop fall-

FIGURE 1. DRY ICE PELLETS used in cloud seeding.

FIGURE 2. WATER SPRAY used for seeding clouds warmer than freezing.

ing through a cloud of small drops will increase very rapidly. However, before the so-called coalescence process can start being effective it is necessary for drops of the order of 50 to 100 microns to be present in the cloud. When drops of this size are found in the cloud, the process of rain formation can be said to have begun because given sufficient cloud mass and time, rain will be produced.

Large drops can be formed in clouds in at least two ways. In many instances clouds of water drops are transported by vertical air motions into regions of the atmosphere having temperatures below freezing. These droplets will remain in the liquid phase until the temperature is lowered to about —40°C unless a foreign substance, a so-called freezing nuclei, is introduced into one of them. If some of the droplets are caused to freeze while some remain liquid, an unstable condition exists because the saturation vapor pressure over water is higher than the saturation vapor pressure over ice. As a result, vapor sublimes on the ice and evaporates from the water droplets and the ice crystals can grow rapidly at the expense of the droplets. In this manner the frozen particle can attain a size at which coalescence can become important.

A second manner by which nature produces large cloud droplets is by condensation on giant condensation nuclei. As indicated earlier, the most clouds have a fairly limited droplet size range. This is a result of the absence of large nuclei. However, in certain atmospheric situations and in some regions of the world, giant sea salt nuclei are present in large concentrations. These giant hygroscopic nuclei can grow to 50 to 100 microns by condensation alone under the humidity conditions associated with rapidly growing clouds.

Cloud Modification Techniques

The requirement of large droplets within clouds to permit the coalescence process to operate rapidly represents the basis on which is established almost all attempts to modify clouds and increase rainfall. Most of the work carried on in the past has employed either dry ice (see fig. 1) or silver iodide nuclei as a treatment reagent. Although operating in a different fashion, these reagents result in the production of ice crystals in supercooled clouds. It is to be particularly noted that a cloud must be at temperatures below and preferably many degrees below freezing before ice crystals will form. Although dry ice will cause the freezing of droplets at temperatures just below O°C, silver iodide does not become effective until temperatures of about −5°C are reached. Dry ice is introduced into a cloud from an airplane. However, silver iodide nuclei can be dispersed either from an airplane or from the ground using one of several types of generators.

In the last few years, cloud treatment studies have been conducted in which water was sprayed directly into building cumulus clouds using an airplane, fig. 2. Attempts have also been made to seed clouds with large hygroscopic nuclei such as sodium chloride. Both of these procedures are designed to introduce into the cloud large water droplets which can grow rapidly by coalescence.

Results of Cloud Modification Attempts

In their earliest cloud seeding experiments, Drs. I. Langmuir and V. Schaefer of General Electric Co. showed that by using dry ice one could cause supercooled stratus clouds to dissipate. They selected supercooled clouds which had a fairly uniform composition over many square miles. Flying indentifiable patterns resembling letters of the alphabet, they dropped pellets of dry ice and then watched for changes of cloud structure. In a matter of minutes the regions of the clouds through which the pellets fell were changed from water droplets to ice crystals. As the latter grew by sublimation of the water vapor evaporated from the droplets, they became large enough to fall out of the cloud. After about 20 to 30 minutes, the patterns of ice crystal clouds resembled the seeded patterns, fig. 3. Through the holes in the clouds produced by the precipitating crystals, one could sometimes see the ground. Similar experiments conducted by others have yielded the same results and proven that the dissipation of supercooled layer clouds can be brought about by seeding with dry ice. If the clouds are at temperatures below −5°C, silver iodide released into them would have similar results.

The dissipation of the stratus clouds was brought about by inducing the transformation of a water cloud containing small droplets into an ice cloud with crystals large enough to fall appreciably. In essence, this is the initiation of the precipitation process. However, the quantity of water in most of these clouds was quite small and the ice crystals did not grow large enough to reach the ground before evaporating. It has been argued that if thicker clouds were treated in this way, the ice crystals can develop into large snow flakes which

would reach the ground as rain after falling into warmer regions and melting. The counter argument states that if such thick clouds were present, they would produce rain naturally. A series of tests have been conducted under different cloud conditions in an attempt to resolve this question.

Most experiments dealing with stratified types of clouds have compared the precipitation falling in an area designated as the target area with that falling in a control area. The cloud seeding is done in such a fashion as to attempt to treat only those clouds over the target areas. In order to make measurements comparable, the areas are taken as close together as possible from the point of view of geography and rainfall characteristics. Unfortunately, precipitation distribution is dependent on local topographic conditions, and at times, the control and target areas are not as similar as desirable. After the experiments have been conducted, the rainfall measurements in the two areas are compared taking into account the natural variability of rainfall as indicated by past records.

Most of the work carried on by the "rainmakers" under contract with such organizations as power companies, farm organizations, and municipalities have indicated that there is almost always more rain following seeding over the target area than over the control area. However, before accepting these results as positive proof of the efficacy of cloud seeding, it is well to consider the difficulties under which seeding is accomplished and the degree of subjectivity used in interpreting the results.

In many of the areas involved, rainfall is measured using sparsely separated raingages. Estimates of the amount of rain falling over an area are made by extrapolating the scattered measurements. Under some conditions, e.g., when precipitation is in the form of showers, this procedure can lead to serious errors. In many cases the length of the records of past precipitation are insufficient to accurately establish the natural variability of the precipitation over one or both areas. The times at which the seeding is conducted is usually decided upon in a non-objective, non-random basis thus permitting the operator to bias the results either consciously or subconsciously. The tests are not designed to permit the application of valid statistical techniques in the interpretation of results because the object of the work is to increase rainfall not to test if such an increase is possible. In addition to these objections, there is the important one which is raised when seeding is done from the ground using silver iodide generators. Because of its simplicity, this is the most frequently used seeding technique. Almost no work has been done to show where the silver iodide smoke goes after it leaves the generator. Since it must reach cloud levels which are frequently above 10,000 ft., this is an important problem. Also, it has been shown that when silver iodide particles are exposed to sunlight and high temperatures, they tend to lose their effectiveness as a freezing nuclei. The rate of loss of effectiveness is still a subject of investigation; however, there is enough evidence to indicate it may be enough to alter the present concepts of the quantity of silver iodide which must be released in order to produce important cloud changes.

The arguments raised in the preceding paragraph are given to show the reasons why most meterologists feel that the question of whether one can increase precipitation over an area is still an open one. The evidence suggests that a small increase is possible; however, the quantity of rain increase, if any, is not known. Before such uncertainties can be resolved, additional experiments must be made which are designed in such a way that the results lend themselves to tests of significance. The large natural variability of precipitation makes it essential that valid statistical techniques be employed in the *design* of the tests as well as the analysis of the results.

Before leaving the subject of the effects of seeding on stratified types of clouds, it should be pointed out that a number of authorities in this field are of the opinion that efforts to increase precipitation would be fruitful when dealing with clouds which form over mountain ranges. It is found that because of the ascent of the air on the windward side of some mountains, there is a continuous production of clouds. In many cases the clouds are carried over the mountains and evaporate on the leeward side without releasing any precipitation. It has been suggested that when these clouds are sufficiently supercooled they can be made to precipitate at least part of the moisture by the introduction of artificial freezing nuclei. From the physics of the problem, this suggestion seems quite feasible; however, it has not yet been tested by experiments in the field.

Some literature has indicated that cloud seeding can be used to change the natural course of development and decay of large atmospheric phenomena such as hurricanes and cyclones. Positive and negative results have been claimed by different researchers. It is the

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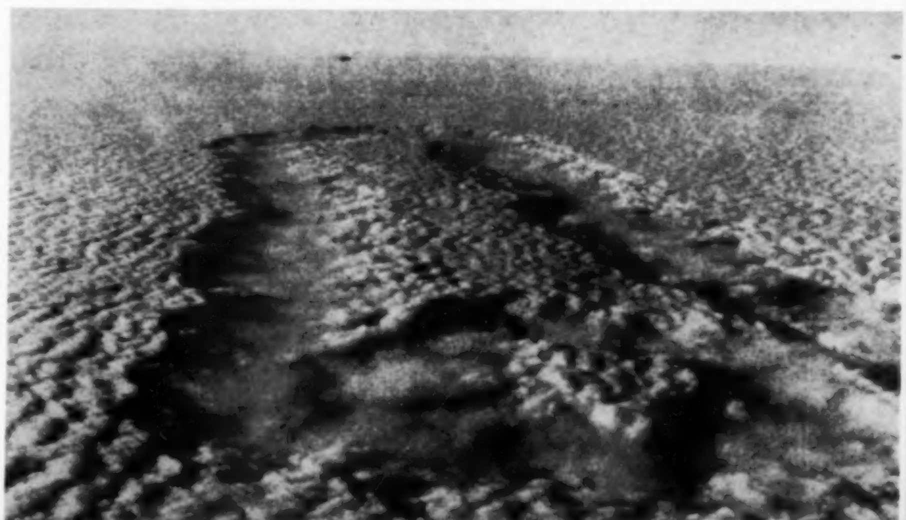
FIGURE 3. EFFECTS OF treating stratus cloud with dry ice. *(Signal Corp. Engineering Lab.)*



The Grand Canyon

(Continued from Page 7)

pacity. Only a small portion of the total area of the Uinkaret Plateau falls within the Monument, and fortunately this segment is least disturbed through livestock abuse simply because it is too far removed from permanent springs or other water supply.

Of the canyon itself, the inner gorge is the only portion of the Monument to have escaped completely all livestock grazing. The insurmountable barriers of Nature, and not man's benevolence or farsightedness, decreed this. Much of the outer gorge also remains in a relatively pristine condition because of its rugged terrain, the scarcity of water and the infrequency of points of ingress, but in one of the major side canyons of the outer gorge, 129 cattle are permitted to graze the area year long.

Proposals for Redesignation of Boundary

The Grand Canyon National Monument currently is under reappraisal by the Parks Service. The report is that a proposed redesignation of boundary lines would vacate most of the juniper-pinyon areas of the Kanab and Coconino plateaus and transfer them to the Bureau of Land Management for administration. One map of these proposed boundary changes indicates that a strip of land one mile wide would follow the contour of the canyon breaks. But since no fence is proposed, such a designation would be wholly ineffective and unjustified so far as the public is concerned.

However, I am persuaded that a redesignation of the boundary would be in the public interest provided that the National Park Service would adhere to the following provisions: (1) Decree that both the outer and inner gorge and the present Monument area of the Uinkaret Plateau be designated as an inviolate wild-life sanctuary and that all present grazing permits be immediately and permanently withdrawn. (2) Provide adequate and necessary buffer areas for the outer gorge. This could be done at small cost by erecting fences across the narrow isthmus of projecting points lying west of Tuckup and S. B. Canyons. It is estimated that a total of 30 miles of effective buffer area could be provided by a total of eight miles of fence. (3) Complete fencing begun in 1941 to insure total protection of the Monument's segment of the Uinkaret Plateau. This would require an additional eight miles of fence.

These proposals in effect would agree to trade about one quarter of the present Monument area, consisting of seriously overgrazed juniper-pinyon type, for thirty square miles of properly protected buffer land, plus an assurance that the redesignated Monument would be managed to preserve its unique biological resource. I am convinced that it would be a good trade for all interests.

Comparatively few people visit the Grand Canyon National Monument annually because of poor roads and the almost total absence of tourist's facilities. A large expenditure of public funds would be necessary to make the Monument attractive to the general public, but a ridiculously small amount would be required to preserve it as a wilderness area of incalculable value for scientific study. ●

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St. Louis University Offers Fellowships

Saint Louis University has been awarded a $10,400 grant from E. I. Du Pont de Nemours and Company for the general support of its Institute for the Teaching of Chemistry, it was announced by Dr. Theodore A. Ashford, Professor of Chemistry and Director of the Institute. This is the second year Du Pont has aided the Institute, which has operated since 1950.

The grant will provide for sixteen fellowships valued at $350 each for Chemistry teachers in High Schools and Junior Colleges, enabling them to attend the University's six-week program of the Institute to be held in the summer of 1956. The applicants need not be candidates for a degree. The Summer Institute program is comprised of five types of activity: special lectures, seminars in special topics of chemistry, seminars on the problems of teaching chemistry, informal conferences and field trips to local industry and laboratories.

The grant will also provide for two fellowships of $1,650 for the support of qualified recent college graduates, who wish to work toward a Master's of Science in the Teaching of Chemistry during the academic year 1956-57. The degree program is tailor-made for graduate training in Chemistry teaching. It combines advanced courses in Chemistry, Physics, Mathematics and Education.

In announcing the grant, Dr. Ashford called attention to the very serious shortage of science teachers and people studying science today, and the concerted effort throughout the country to alleviate the problem. He said that it is a problem which concerns the government, industry, the National Science Foundation, scientific societies and universities.

It is encouraging, he added, that industry has seen fit to support the teaching of Science and Mathematics teachers, and that Du Pont has given its support to aid the Institute at Saint Louis University.

Qualified applicants may write directly to: Dr. T. A. Ashford, Director of the Institute for the teaching of Chemistry, Saint Louis University, Saint Louis, Mo., for further information concerning the fellowships and a bulletin describing the Institute.

Study of Micro-Morphology

(Continued from Page 17)

the single method of fixation now in use or develop more suitable fixation processes for study and differentiation of the components of the cells. But a really more basic limitation in all our observations with the electron microscope on living organisms exists, for in the process of preparation of specimens for each experiment the treatment must be such that at the very best only a fixed array of a formerly dynamic system is obtained. Given the complexity of the biochemical and physiological process in these living organisms a series of static observations made with the electron microscope alone, be they ever so many, does not make it possible to introduce a time scale into the process under study. Of course this is the challenge to man's intelligence. He cannot hope to observe all of the life process with the one instrument alone, but using it together with the many other physio-chemical methods now developed he can search and probe, confident that properly understood the data obtained will all correlate; for to man has been given the ability to see ever deeper into the nature of the world in which we live. ●

Secularism in Science

(Continued from Page 11)

the empiriological disciplines uncover and verify by experiment, is preposterous. There are many things which cannot possibly be explained by science. A scientist could never prove, for instance, that a thing can not be and not be at the same time. Yet would any one dare to say that since it can not be proved it is not true. Certainly not! Science is good. It has helped man in innumerable ways in the fields of medicine and technology. Science for its own sake is certainly a lofty pursuit which can enable man to delve deep into the mysteries of nature. As long as the desire for truth remains embedded in human nature science will be with us. Science in its pure form, that is, when considered apart from the technological advances it gives us, is undoubtedly one of the most worthy pursuits of the human intellect. Science is certainly an expression of one of the noblest traits of man—his desire to possess the truth. The scientist, however, must beware of these systems of thought which would turn his method into the be-all and end-all of all knowledge. ●

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★ ★ ★ ★ ★

New ACS Examinations

A new test in organic chemistry, Form MB, has been prepared by the Organic Subcommittee under the chairmanship of Bernard A. Nelson, of Wheaton College. This is a test for the brief courses usually given in one semester.

The General Chemistry Subcommittee under the chairmanship of Donald D. Wright of Brooklyn College, has prepared a new test in general chemistry, form M. As in previous forms, the test covers the field of general chemistry. It consists of a section on information, one on application of principles and one on equations and problems.

These two tests are part of the spring testing program sponsored by the Examinations Committee. Several forms are available in each of the fields of General and Organic, and in Qualitative, Quantitative, Physical and Biochemistry.

Further information and copies of all the tests may be obtained from Theodore A. Ashford, Committee

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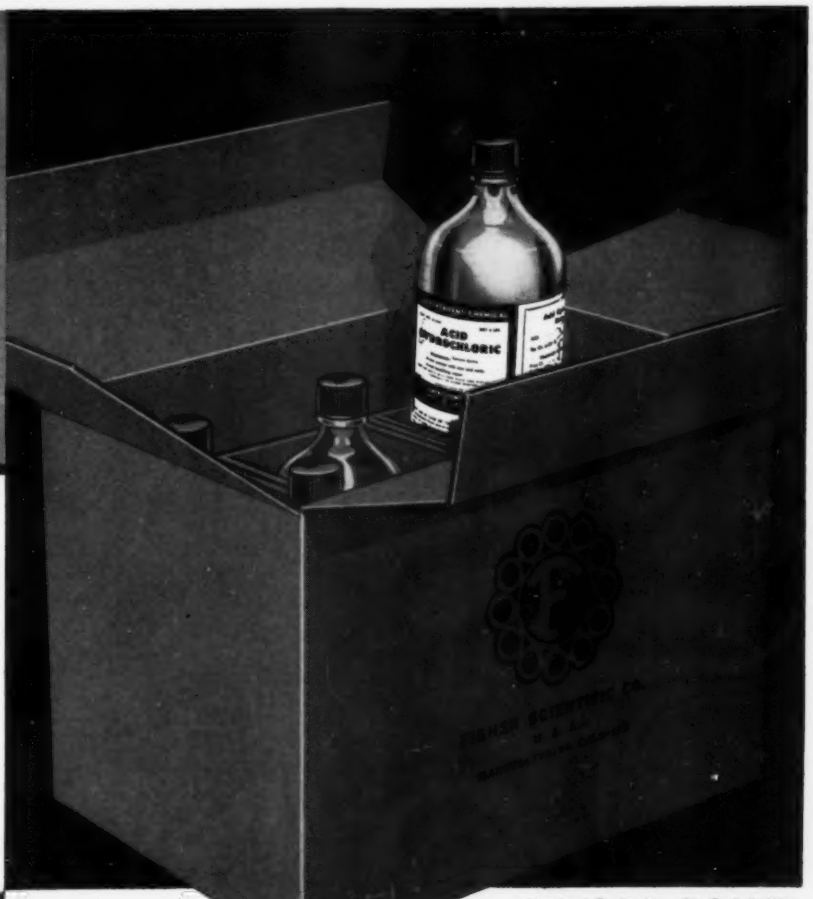

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Analysis—Key to Chemistry

(Continued from Page 4)

Separation by Fractionation—Chromatography

Chemical engineers have long recognized that the same fundamental thermodynamic law governed all types of separations whether the fractionation involved a separation based upon differences in boiling point, solubility or absorbability upon a solid[3]. As an example of the operation of the principle, it is convenient to carry out a chromatographic separation employing filter paper as the adsorbent and the differences in adsorbability of organic indicators as the basis of the separation. Extremely small amounts can be separated into distinct bands or spots[4].

Experiments

1. Cut large sheets (4-8 inches in diameter) of filter paper into one-inch strips. About one and a half inches from one end, add in a row across the strip, one drop portions of two or three acid-base indicators. Crease the strip about one inch from the same end and dip the short portion into a nearly full beaker of water. Note that water flows by capillary action through the sheet to and beyond the spots of the indicators. After 10-20 minutes the water will have traveled about four inches and (with luck in selecting the indicators) each spot will have traveled a different distance with the water. The spot for each indicator will often remain discrete, though it may stretch out longitudinally.

Indicators like phenolphthalein, which are colorless in one form, can be made visible after separation by blowing fumes of ammonia or hydrochloric acid onto the paper. After finding two or more indicators that separate in a chromatographic procedure, one can boldly mix the drops on the paper before carrying out the development. However, it is helpful to the class if the separate spots are first developed before doing the mixture. Variations can be introduced by using acidic or basic solutions to "develop" the indicator stains instead of water.

2. One can also separate ions such as copper (II), cobalt (II) and nickel (II). After development, the zones can be made more readily visible by reacting the ions with organic reagents, which produce colored compounds, or with dilute solutions of sodium sulfide. According to the literature[4] solutions of butanol treated with hydrochloric acid or ammonia seem, in general, to be the most effective developers.

Conclusions

The experiments outlined above can be carried out with relatively simple and comparatively inexpensive apparatus. Each of them has the distinction of being extremely sensitive to small amounts of material when used under optimum conditions. However, their chief virtue is their usefulness in illustrating basic chemical principles. Largely as a result of the application of methods such as these, the field of analytical chemistry has largely regained its original position as "The Key to Chemistry." ●

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★ ★ ★ ★ ★

"The material to be covered in any particular subject of instruction needs to be carefully selected. It is generally not possible to cover the entire subject. The most successful instructors are often those who teach less material but do it profoundly. We should aim not to cover the subject but to uncover part of it."

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Detergent Builders

(Continued from Page 14)

5. *Synergism*—When complex phosphates are used as builders with a synthetic detergent, the resultant detergency is greater than the combined effect of the complex phosphate, and the synthetic detergent acting independently.

It is a combination of the above described properties and probably other properties not as yet fully understood that make complex phosphates ideal builders for detergents.

Organic Builders and Additives

A wide variety of organic substances, other than the detergents themselves, have found their way into the blending of cleaning agents. In most cases these are added in order to increase the detersive effect and in other cases to impart special properties to the mixture.

Colloidal Additives—Possibly the most important group of organic builders consist of water soluble polymeric substances such as gums, starches, proteins and cellulose derivatives. Sodium carboxymethylcellulose, which is added to most of the household and industrial synthetic laundry detergents, is perhaps the most widely employed colloidal additive primarily because of its soil antiredeposition effect particularly in cotton detergency. Apparently the cellulosic portion of the molecule is adsorbed by the cellulosic cotton fiber and the carboxymethyl groups projecting from the fiber exert an electrostatic repulsion for the dirt particles thus preventing soil redeposition. Sodium carboxymethylcellulose is produced industrially by the etherification of alkali-treated cellulose with sodium chloroacetate either batchwise or by a continuous process.

Certain other carbohydrate gums and starches as well as methyl and hydroxyethyl cellulose have been used in this connection and many others have been recommended. However, carboxymethylcellulose appears to be unique in its soil-suspending qualities among the organic builders. In certain cases, these colloidal agents are used in specialty products such as shampoos and liquid detergents to give high viscosity and an appearance of high concentration. Some of them also possess a desirable emollient effect on the skin particularly in hand-dishwashing compositions.

Urea is sometimes employed as a solubilizing agent for various detergents and as an inexpensive though innocuous filler in preparations for personal use. Urea possesses the ability to peptize colloidal materials. Urea also forms solid complexes with some of the liquid nonionic detergents of the polyoxyethylene type thus increasing their suitability for blending.

Sequestering Agents are employed in certain specialty cleaning preparations particularly to preserve clarity in liquid soap products. The most important of these is ethylenediamine tetraacetic acid (VI), usually as one of the

$$(HOOC\text{-}CH_2)_2\text{-}N\text{-}CH_2\text{-}CH_2\text{-}N(CH_2\text{-}COOH)_2 \quad \text{(VI)}$$

sodium salts. However, their high cost limits general usage. More recently, the aldonic acids (VII) and particularly gluconic acid have come into use where highly

$$HO\text{-}CH_2\text{-}(CHOH)_4\text{-}COOH \quad \text{(VII)}$$

alkaline solutions are used, for example in bottle washing. These sugar acids prevent the formation of heavy lime deposits on the machinery used in the cleaning process.

Optical Brighteners—A number of aromatic compounds which are substantive to fabrics absorb ultraviolet light and give a reflection in the blue region of the visible spectrum. The use of these substances in detergent mixes results in a whiter appearance of the laundered material since yellowish casts are masked. These brighteners may be classified as "white dyes" and must be water soluble, possess stability to hypochlorite bleaches, be selectively adsorbed by the fabric from aqueous solution in addition to their optical requirements. The structures of these dyes center around amino and sulfonic acid stilbene derivatives. However, a large variety of similarly substituted aromatic and heterocyclic fluorescent dyes have been proposed as optical brighteners both for cotton and wool. It may be mentioned that one of the earliest brighteners employed extensively following the second world war was betamethyl umbelliferone, a coumarin derivative. While this latter substance is not substantive to textiles, it was used to whiten soap.

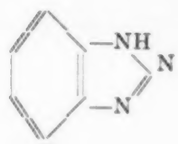
Foam Stabilizers—A number of fatty acid alkanolamides (VIII, IX) are

R-CO-NH-CH_2-CH_2-OH (VIII)   R-CON-(CH_2-CH_2-$OH)_2$ (IX)

employed as additives because of their ability to stabilize the foam of a detergent mixture particularly in the presence of greases. These substances are usually prepared by condensation of fatty acids with alkanolamines and the reaction products, though represented by the typical formulas VIII and IX, may contain minor proportions of more complex structure. The mechanism of foam stabilization by the alkanolamides has not been experimentally determined.

It should be mentioned that these substances are being used in ever-increasing quantities to stabilize foam particularly in hand-dishwashing compositions.

Corrosion Inhibitors—Alkaline solutions in general tend to tarnish and even corrode various metallic parts of washing machines, particularly when the protective oxide coating has been sequestered by the polyphosphates. Brass, copper, zinc and aluminum parts are especially affected by these solutions. Although the silicates tend to reduce corrosion, recently a number of heterocyclic compounds possessing triazole and thiazole ring structures have been patented as additives for these compositions to further reduce tarnishing of the metallic parts and some of these substances are in commercial use. Among the more common additives in actual use are benzotriazole (X) 2, mercaptobenzothiazole (XI) and Thialdine (XII).



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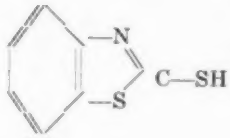
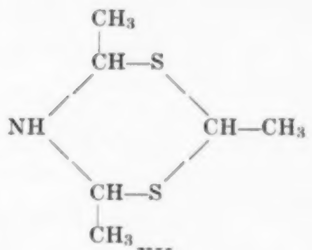


XI



XII

Summary

Blending a detergent mixture is no longer a simple matter. Consideration must be given to the type of cleaning one desires and the various additives and builders which will impart the necessary properties to a particuar product should be incorporated, therein. ●

★ ★ ★ ★ ★

"'Science as fact is neutral, with great possibilities for evil looming up behind the neutrality. As a method of inquiry, however, it can only be regarded as on the side of the angels and as offering a positive basis for hope."

—JULIUS SEEYLE BIXLER
in *Mid-Century*

Sound National Water Policy

(Continued from Page 9)

of 1902 was passed by Congress, irrigation was largely in private hands. This law was designed to encourage reclamation by providing a relatively small subsidy through sale of public lands and use of a revolving Reclamation Fund. This fund was used to advance construction costs for reclamation projects, and settlers were to repay these costs over a ten-year period without interest. From the very first the plan was not successful and the subsidy was gradually increased by lengthening the interest-free repayment period. It was only with the advent of the emergency relief appropriations of the 1930's, however, that the Reclamation Bureau became the empire it is today. As more and more grandiose schemes were envisioned it became clear that the subsidy to farmers would have to be greatly increased if the "good work" were to continue.

The Reclamation Project Act of 1939 paved the way for construction of projects that will be a burden on the general taxpayer for a century. Several outgrowths of this legislation require examination. The benefit-cost ratio employed by the Bureau would be a perfectly sound device to assess the worth of a project if it were properly used. Unfortunately, as employed by the Bureau, it lends itself to tortured application. Projects have been justified by underestimating costs and overstating the monetary value of presumed benefits.

It has long been accepted as a national policy that irrigation projects be subsidized. As the cost of reclamation projects increases, however, the benefits to be derived from irrigation should be compared with the benefits from expenditures of like sums to increase agricultural projection by any other means at any other location in the United States. Certainly, reclamation needs a sound, firm and specific national policy if it is not to get completely out of hand.

A bill (HR 1824) to establish a national water policy has been introduced in this 84th session of Congress. This bill is similar to one (S 3606) which was introduced in 1954 and which died in committee. This bill contains both good and bad features, but in the main it does not go far enough in spelling out essential elements of a sound policy. Failure to provide for an impartial Board of Review to analyze and appraise Federal water projects is one of the most serious shortcomings of HR 1824. In addition, some of its provisions are self-contradictory.

Long ago a wise Frenchman (Joseph de Maistre, 1811) wrote, "Every country has the government it deserves." Let us hope the Congress does not enact the kind of water policy some of us now seem to deserve. ●

★ ★ ★ ★ ★

Acids, Bases and Cabbage

(Continued from Page 12)

obtained. Even when final conclusions cannot be reached with certainty, the youngsters will have had a worthwhile science experience.

e. Some of my students have added the cabbage juice to test tube cultures of bacteria to find out if the organisms could be classified as acid forming. For this purpose we sterilized the juice (separately or as a part of the culture medium) in a pressure canner and it has kept for several weeks without refrigeration.

Other Possibilities

Blueberries, purple plums, purple onions and many other foods contain anthocyanin. These may, with some investigation be used in a similar way as an indicator. They are certainly worth discussing when classrooms activities involve indicators and acids and bases. This will help a youngster understand why that blueberry stain on his white shirt was green when it came back from the laundry.

It would seem as though the material in the preceding paragraphs might serve to stimulate some worthwhile science fair projects for either junior high or senior high school students.

Almost all of the ideas discussed in this article have been used in a modified form with elementary school youngsters and elementary school teachers groups. The fascination of the color changes and the inexpensive availability of large quantities of the juice make this a successful area for science activities in the elementary school. ●

The Story of Stained Glass

(Continued from Page 8)

use of pictorial detail. It lends itself well to abstract and non-objective forms, and has the additional dimension and depth which is not found in glass of a thinner gauge. It will never entirely replace traditional stained glass, but it is opening new vistas in the field of architecture, and is an influential source of inspiration, creating a definite place for itself.

Pure color in light has the power of lifting the observer out of himself. As you look at stained glass windows you can feel the spirit of the men behind them. The earliest windows stir within one the idea that their designers and makers were eager minded citizens of an active world, aglow with imagination and courage. Then came an era of decadence, when efforts were made to depict paintings in glass—a sad time—when the glory of glass itself as a medium was lost.

Now we have seized upon the sparkling jewels of glass with the ardor of discoverers and are building them into honest psalms of praise in color and light.

The mediaeval craftsman had no preliminary sketch, nor had he paper patterns. His first step was to smooth a wooden slab twice the size of a window panel. On this he scraped chalk, sprinkled it with water, and spread the paste around until the entire board was covered. He measured off the size of the panel on half the board, and carefully drew such figures as he desired, going over the lines with red or black, perhaps with the very same colors used by the monks for illuminating manuscripts in the scriptorium. The drawing served not only as cartoon, but also as cutline and pattern, and later for tracing the significant form.

In the Middle Ages the glass was cut with a tool which was nothing more than a sharply pointed rod of iron, heated to a high temperature. The red hot point was drawn along the moistened surface of the glass placed over the chalked cartoon, and the glass snapped apart. The fracture was not very accurate and the rough place had to be chipped or grozed down to the exact shape with the help of hooked tools called grozing irons.

★ ★ ★ ★ ★

It was the failure of the religious leaders of Darwin's day, excited by the violent attacks made on religion by the apostles of evolution, to remember that the Bible is a revelation of spiritual verities, not a textbook of natural science, which was in no small part responsible for the fury and length of the controversy on evolution. Indeed, this failure has played a part in almost every conflict, or rather in every imagined conflict, between science and religion. It is necessary to remember that while the sacred writers communicate great spiritual and religious truths, they reflect merely the views on natural science prevalent in their day.

JOHN A. O'BRIEN, C.S.C.,
"The Origin of Man"

New Books

Introduction to Parasitology

• *By* ASA C. CHANDLER, Ph.D. Ninth Edition. New York: John Wiley & Sons, Inc. 1955. Pp. 799. $8.50.

Former editions of this textbook have been favorites in the field of parasitology for over 35 years. An outstanding feature of each edition has been the highly readable style in which they have been written. Although the material is essentially of a technical nature, it has been presented in such a manner as to arouse and hold the student's interest.

This ninth edition has been designed to bring certain aspects of the field up to date. For instance, greater emphasis has been shifted to some of the parasitic diseases that command increasing interest in the world today, e. g., amebiasis, schistosomiasis etc. Sections on immunity, insecticides, and the classifications of arthropods have been almost completely rewritten in order to include new developments in these fields.

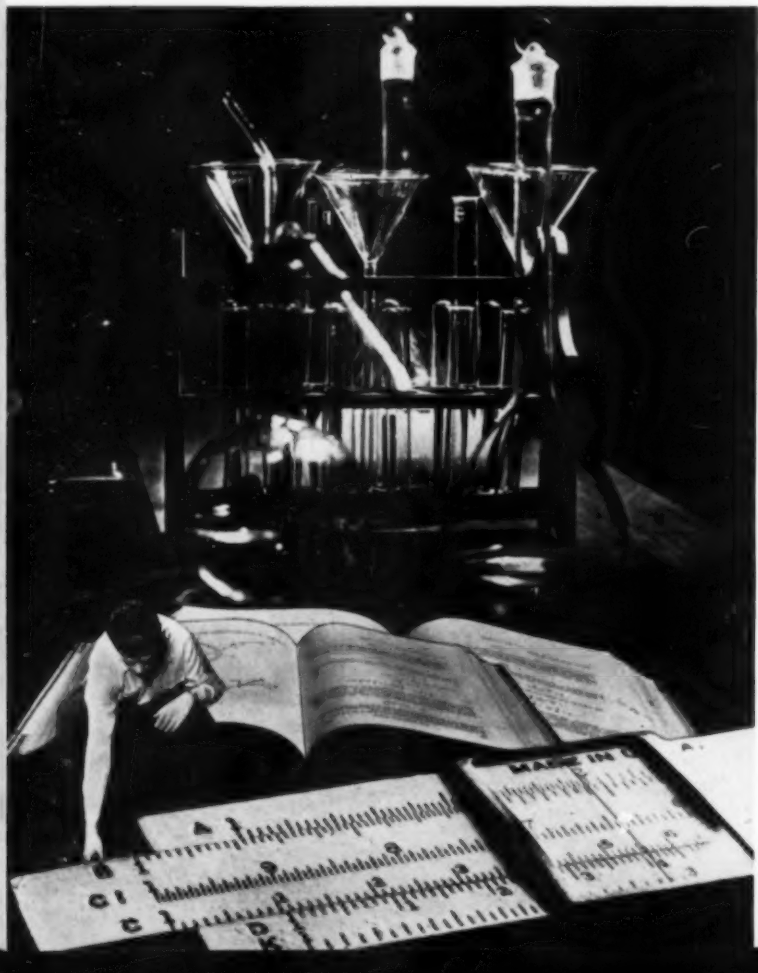
As in previous editions, the book is clearly illustrated with concise and detailed drawings. In addition, lists of important references are included at the end of each chapter, enabling the student to go further into each subject, if he so desires.

One of the essential features of this last edition is the inclusion of recent and detailed information on such topics as: the use of penicillin in the treatment of syphilis, arthropod-borne virus infections, new treatment techniques for pinworm infections; the epidemiology, treatment and control of African trypanosomiases of man and animals, and many more.

From experience in the classroom, I would highly recommend this book as a basic text in parasitology, not only for its wealth of information, but also for its general readability and appeal to the interest of the students.

Lois R. Gmitter, Ph. D.
Dept. of Biology
Duquesne University

Photo by Vic Kelley



Physics A Descriptive Interpretation

• *By* C. H. BACHMAN. New York: John Wiley and Sons, Inc. 1955. Pp. VIII + 497. $5.50.

This is an excellent text for a one or two semester course in physics for non-science students. It is thoroughly modern in content and highly readable in style. Unlike many texts for terminal courses, it is not an adaption of the standard first course in physics. The student who follows a course based on this text, or the interested reader, will acquire a sound introductory knowledge of modern physics.

The most remarkable feature of the text is its arrangement. After a short introduction the author treats microcosmic physics, macrocosmic physics and cosmic physics in that order. This break from the traditional order in physics texts, enables the student to obtain a much clearer concept of the quantum theory and particle physics. The later sections deal with some of the common applications of physics.

This book should be in every college and high school library. *J. P. M.*

Classics of Biology

• *By* AUGUST PI SUNER (Authorized English translation by Charles M. Stern) New York: The Philosophical Library, Inc. 1955. Pp. X + 357. $7.50.

This book is not just an anthology of the classics of biology but an authorative survey of the progress of biology. In each chapter a broad, fundamental problem is clearly and concisely discussed and the author closes the chapter with an excellent selection of highly pertinent extracts from the writings of outstanding authorities.

The outstanding characheristic of *Classics of Biology* is its logical unity. Each extract is skillfully integrated into the author's discussion. If the author's acknowledgments were omitted it would, at times, be difficult to determine where the author closes his discussion and where the extract begins. To attain this unity the extracts are arranged in logical rather than chronological order.

The translation from the original Spanish is excellent. In the preface the translator states that he has taken the opportunity of returning to the originals of the classics selected by the author and rendering them afresh into English. Where the original is in English the original text is quoted.

The author, Dr. August Pi Suner is the winner of the 1955 Kalinga Prize, for his work in popularizing science in the Spanish-speaking world. This prize is offered annually by UNESCO to recognize competent interpretation of science to the general public.

J. P. M.

200 Miles Up

• *By* J. GORDON VAETH. Second Edition. New York: The Ronald Press Company. 1955. Pp. XIII + 261. $5.00.

This book is a factual account of man's progress in conquering space. It is written in an interesting non-technical style, but the author's skill is such that scientific accuracy is always maintained.

The early chapters discuss our present knowledge of the atmosphere, define the various regions of the atmosphere, explain the methods and instruments used in collecting atmospheric data and call attention to the peace time importance of knowledge concerning the atmosphere. The actual vehicles used in conquering the atmosphere are described, evaluated and their limits are defined. The author closes with some speculations concerning the future of the conquest of space but does not make any predictions which cannot be justified by present data.

This reviewer found the chart of the upper atmosphere, which is printed on the front and back fly leafs, very helpful in reading the text. The typography and illustrations are excellent. *J. P. M.*

Two Ears of Corn, Two Blades of Grass

• *By* D. H. KILLEFFER. New York: D. Van Nostrand Company, Inc. 1955. Pp. x + 384. $4.00.

Two years ago, a religious writer in *Social Order* endeavored to allay the fears of those who condemn the machine age. He pointed out how its dangers are accidental abuses in the use of what is essentially good. He wrote:

> "For it is not essential to the machine and technical progress that they mechanize and enslave men who work with them. On the contrary, it is precisely one of the most momentous consequences of the modern technological revolution that for the first time in history it has put within the reach of man the realistic possibility of liberating human labor from its most oppressive and brutalizing characteristics."
>
> W. Norris Clark, S.J., *Social Order, May-June* (1953, *p. 284*).

For those who hold Father Clarke's thesis — that for man to work actively and creatively is to fulfill God's plan — this work of Mr. Killeffer should be interesting. The author shows how the enhancement and humanizing of man's life brought about by the machine will be dwarfed by the development in the field of chemistry.

Perhaps some may take issue with the author, in the promise of universal happiness which he implies and the world peace which he envisages. They will say that happiness and world peace postulate something more than material satisfaction. We think, however, that such an objection would be captious. Although the author does not mention religion, his program ties in, in several salient points with the plan of Christian Humanism outlined in *Social Order.* The book reveals this indirectly; it shows itself in the author's grasp of the fact that men have in their striving for spiritual things, been frustrated by material things (or their absence), by the basic human problems of nutrition, health and resources.

How chemistry is helping to solve those problems is the theme of the book. It shows how science, from an inexhaustible field of raw material, is able to produce food, drugs, power and the other necessities of life. It is not a philosophical work. Only in the first and last chapters does the author pursue directly what he calls the gist of the work — the attainment of universal peace. His arguments there are powerful, as every student of economic history can see.

The other ten chapters are powerful too, but from another viewpoint. The story of penicillin and sulfanilamide, of atomic fires, of the processing of metals, of power and speed, medicine and drugs — all from the Synthetic Kingdom — is given in lucid style.

Herman J. Flynn, C.S.Sp.
Department of English
Duquesne University

Semimicro Laboratory Exercises in High School Chemistry

• *By* FRED T. WEISBRUCH. Boston, Mass. D. C. Heath and Co. Pp. VIII + 277. $1.88.

Those who have tried the semimicro method in high school chemistry have found it to be an excellent method of teaching chemical principles. Ten years ago many objected to it because they believed that the student would be so absorbed in technique that he would not see the principle the experiment was designed to demonstrate. Ten years of use has demonstrated that the results of semimicro experiments are just as evident or more evident than those of the macro method.

This second edition of an established semimicro laboratory book has an excellent selection of experiments suitable for one hour periods. It is paper bound 8x11½ inches with pages perforated so that the exercise can be handed in for correction. In the preface the author mentions a teacher's handbook which this reviewer has not seen.

Teachers who are teaching chemistry courses with or without laboratory should investigate the possibilities of this manual.

J. P. M.

Basic Mathematics for Science and Engineering

• *By* PAUL G. ANDRES, HUGH J. MISER and HAIM REINGOLD. New York: John Wiley and Sons, Inc. Pp. VII + 846. $6.75.

This book, as the title implies, is intended for students interested in applied mathematics. The authors have all taught at the Illinois Institute of Technology and are well qualified. College algebra, trigonometry, analytic geometry and an introduction to calculus are presented in this text.

There are many strong points in this book. The authors use simple wording in their explanations. Simple operations on the slide rule are included. They introduce quite early the accuracy of computations and readings, and they emphasize them throughout the text. There are some 650 worked out examples and over 7,000 exercises, many of which are physical applications of the principles being studied in that particular section. The book is well illustrated with good graphs. An introduction and summation are features of each chapter. There are two good chapters on vectors and complex numbers. A review of fundamental geometry, four place tables and answers to the odd problems are given in the appendix.

The book is too large for an ordinary one year college course. The authors fail to introduce synthetic substitution and division which is a real oversight. The trigonometric formulas for sums of angles could have been developed instead of merely stated. There was too much space devoted to the number two as a base of a logarithmic system.

Though large for a text, this book would make an excellent reference book for any student interested in basic applied mathematics. The explanations are clear enough for self-study.

Donato A. DeFelice
Department of Mathematics
Duquesne University

★ ★ ★ ★ ★

Negative Proton Discovered

Since the discovery of the positive electron there has been much speculation as to whether a negative proton could exist. On the basis of pure mathematical theory, it should. But if so, it is very rare. In 1951, Dr. J. G. Retallack of Indiana University (USA) found a record on a photographic plate exposed to cosmic rays which, he thought, could have been caused only by a negative proton. In 1954, Dr. Rossi of the Massachusetts Institute of Technology (USA) also obtained a "most unusual" cosmic rays photograph which seemed to indicate the passage of a negative proton.

But on September 21, 1955, a group of investigators at the University of California used their large "bevatron"—a machine that can accelerate charged particles and give them an energy of six thousand million electron-volts—to hurl high-speed protons at a material target such as a strip of copper. When a proton strikes a neutron in the copper atom, the enormous energy of the flying proton is converted into particle form and two particles emerge from the collision—an ordinary proton and a negative proton. The latter has now been named the anti-proton. Its mass and its charge were accurately measured in October, which thus at last established the existence of the anti-proton.

But it does not exist for long. In a world made up of atoms it is bound to collide, sooner rather than later, with the positive proton of an ordinary atom. When this takes place the proton and the anti-proton annihilate each other and both vanish in a burst of energy.

Thus the theoretical scientists are happy to have established a "balance of nature." As the negative electron has an opposite in the positron, so the positive proton has an opposite in the anti-proton. Just as the two types of electrons annihilate each other, so the two types of protons do also.

—GERALD WENDT (UNESCO)

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"Let us not then exalt the scientific method unduly as the close preserve of the scientist nor, which is more important, as the only means by which we attempt to discover the secrets of Nature. It is easy for the scientist to be a materialist if he sees only in the Universe the apparently relentless unfolding of natural law and forgets that there are domains where the laws of physics are irrelevant."

—W. M. SMART

Artificial Cloud Nucleation

(Continued from Page 21)

opinion of many meteorologists, based on considerations of the energy involved in one of these large scale circulation systems, that treatment with practical quantities of dry ice and silver iodide can have no important effect. From the evidence at hand, it must be concluded that although it may be possible to modify large scale weather systems, this possibility has not yet been demonstrated.

Some of the most positive conclusions regarding the effects of artificial cloud nucleation have come from research dealing with building cumulus clouds. These tall cauliflower-type clouds frequently grow to temperatures well below freezing before the water droplets begin freezing. They are more amenable to seeding experiments than layer type clouds because they are fairly isolated and easily identified. Thus one may select one of a group of clouds, seed it and compare its behavior with the others of the group. Tests have been made on these clouds in several parts of the world.

In Australia, scientists conducting studies in cumulus clouds concluded that it was possible to induce precipitation, by seeding with dry ice, in clouds which would not have precipitated naturally. In order to ascertain that the clouds involved did not contain precipitation before the treatment, and to observe the growth and spread of the rain (if any) subsequent to treatment, they used radar. Certain types of radar sets can detect the presence of droplets large enough to be considered as rain. In this way, objective observations can be made of the formation or nonformation of precipitation.

A group of meteorologists at the University of Chicago have conducted treatment experiments in cumulus clouds in Puerto Rico and the Central United States. They also used radar to observe precipitation. In order to make the data suitable for statistical analysis, clouds were selected in pairs and one cloud of each pair was randomly treated. It was found that by treating tropical cumuli with water, one could induce precipitation in clouds which probably would not have rained naturally. The results of dry ice treatment in the larger clouds over the United States were not conclusive because the sample size was too small. The tests did suggest that the seeding had a small positive effect; however, the sample size was too small to be considered significant.

From the experiments in isolated cumulus clouds carried out under rigid controls, it may be concluded that having the proper type of clouds one can increase the probability of the occurence of precipitation using the proper type of treatment reagents. Little can be said at this time regarding the increase of precipitation at the ground; however, the available evidence indicates that it is possible to produce a small increase of the precipitation falling over particular areas.

It is obvious that a great many questions dealing with this subject remain partially or entirely unanswered. This is mostly a result of the lack of suitable measurements. Since no two cloud systems are identical, it is necessary to treat most of the problems in a statistical fashion with the requirement of adequate sample size. This means of course that research in this field is expensive and time consuming. It is therefore to be expected that progress in this field should be slow. However, over the last ten years a great deal has been learned about the natural precipitation processes and the effects of artificial cloud nucleation. If adequate funds are made available for continued research, our understanding of the physics of cloud and rain growth will continue to grow. ●

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"The persistency of errors is a fascinating phenomenon. A number of different studies with various kinds of material have all emphasized that the worst learners are not those who know nothing whatsoever about a situation but those who know the wrong things."

—HARRY KAY *in a radio address "Adult Learning and Remembering."*